INSIDE: Summer Astronomy Guide

ASTRONOMY

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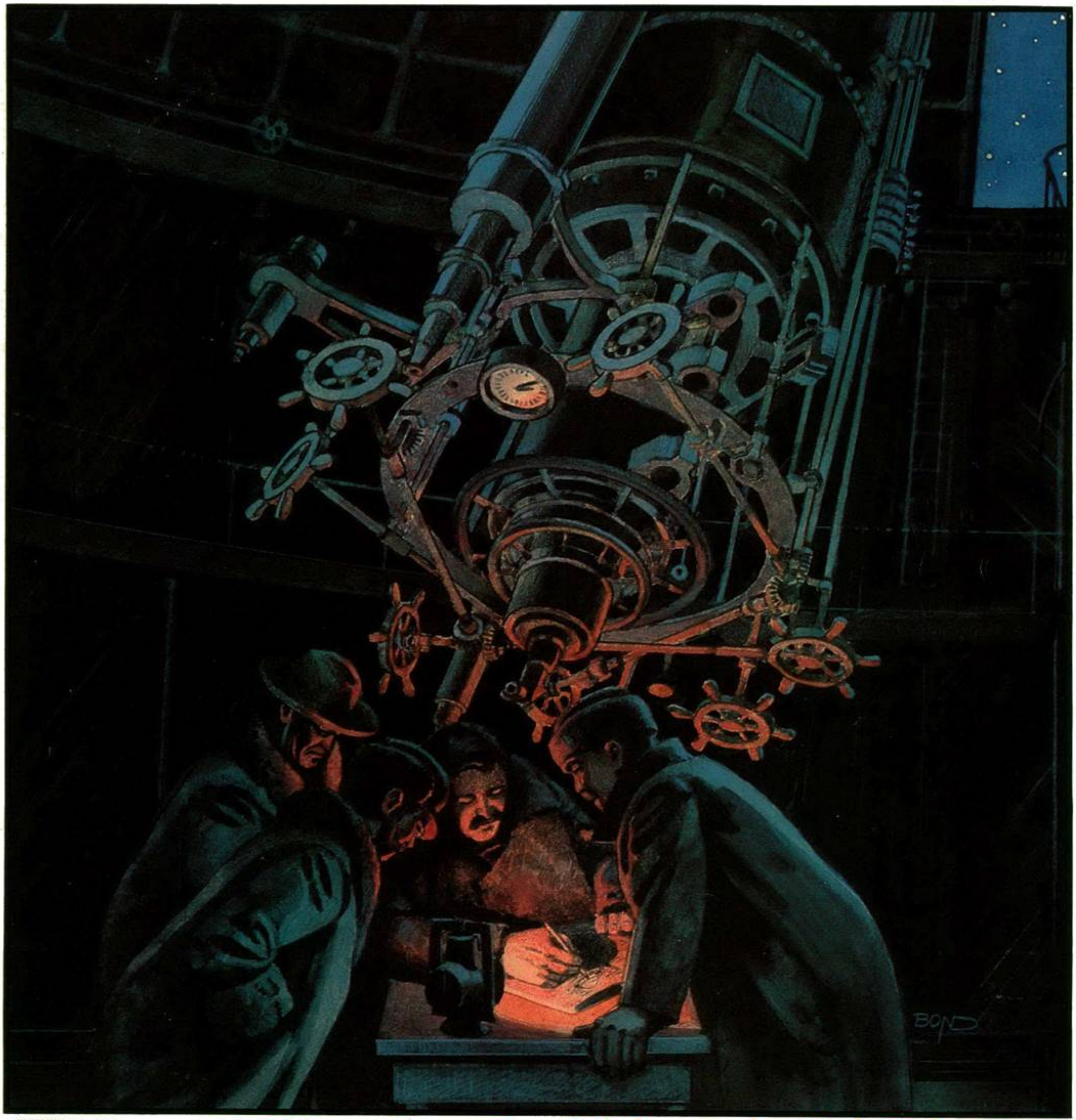
Pioneer Astronomers at Lick

Reader Poll: Manned Missions Lead

Radio Astronomy Looks to Space



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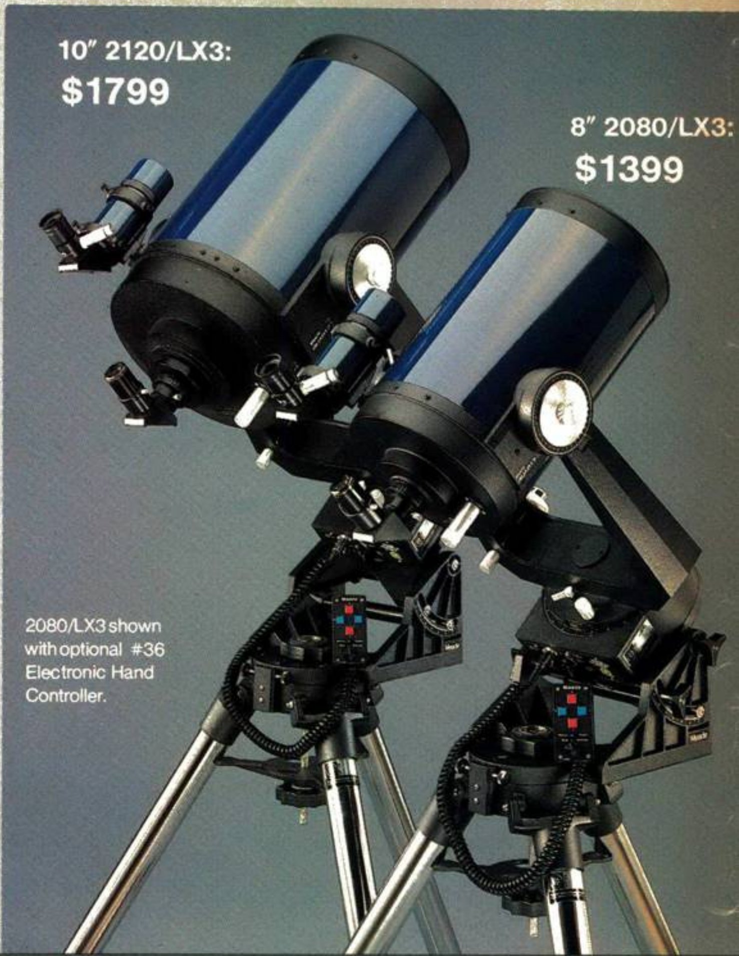

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Cover: The first view of Saturn through Lick Observatory's 36-inch telescope took place on January 7, 1888. Although the dome was frozen and could not turn, the hardy astronomers opened the slit anyway. James Keeler sketched the planet. Painting by Bruce Bond. Opposite page: Are you ready for the magnificent nights of summer stargazing? Turn to page 60 for our 1988 Summer Guide. Painting by Barbara Ericksen.

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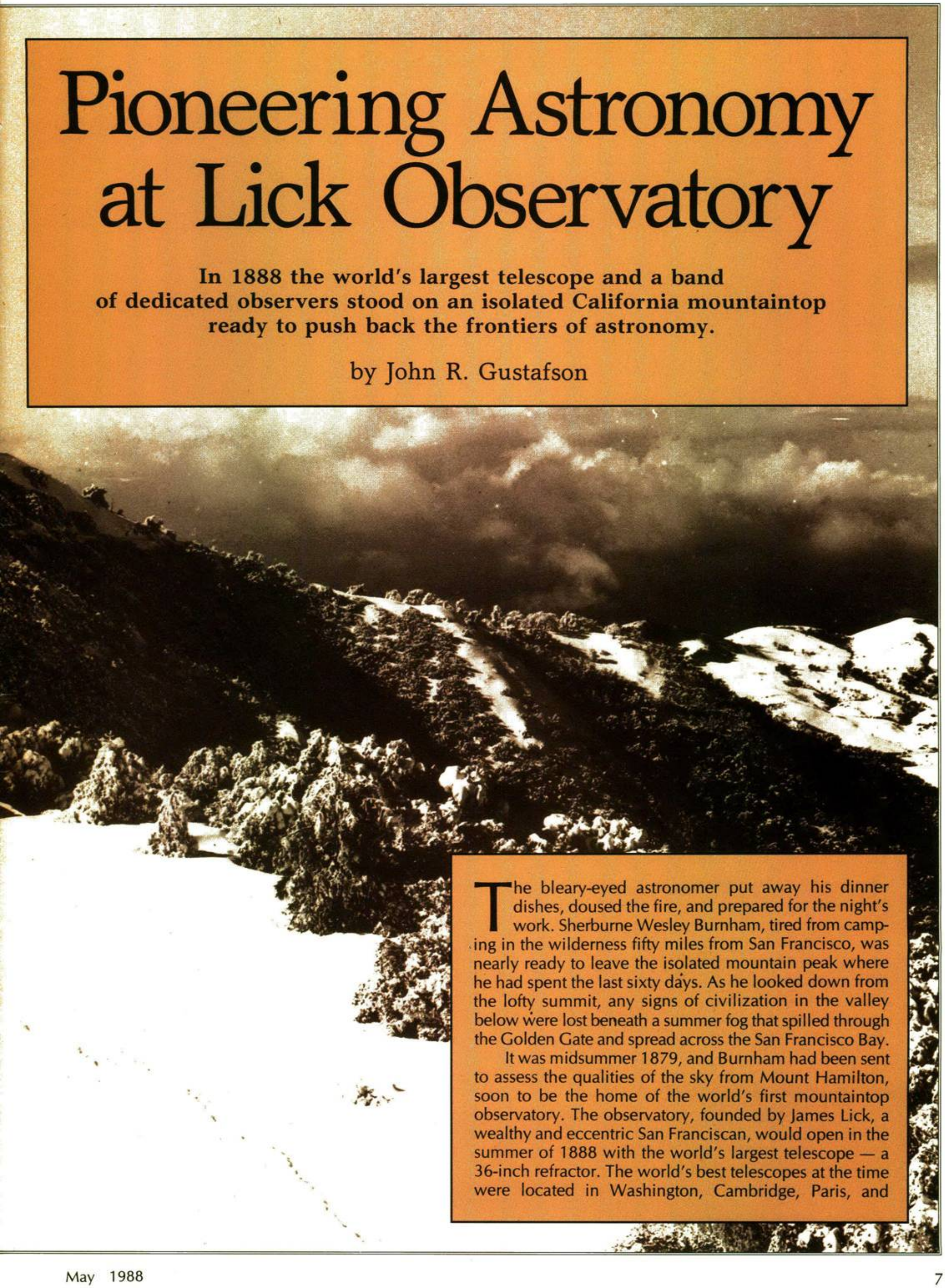
Pioneering Astronomy at Lick Observatory

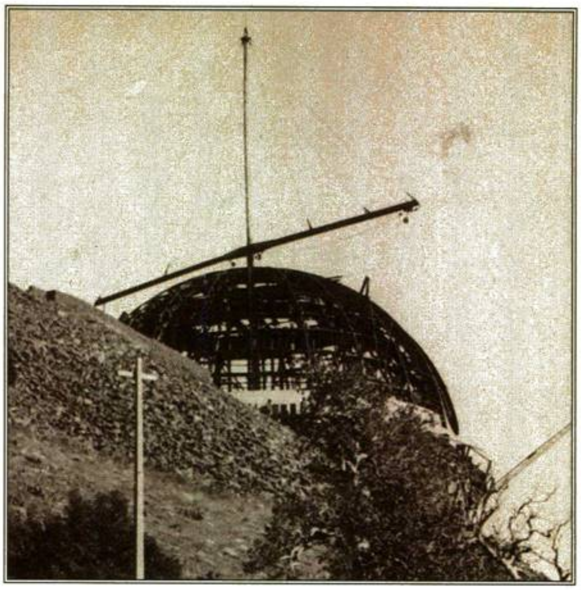
In 1888 the world's largest telescope and a band of dedicated observers stood on an isolated California mountaintop ready to push back the frontiers of astronomy.

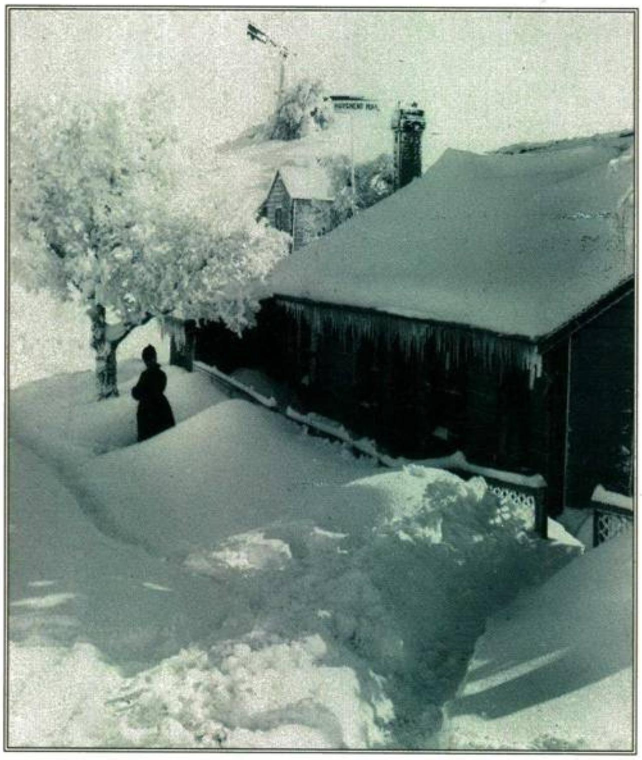
by John R. Gustafson

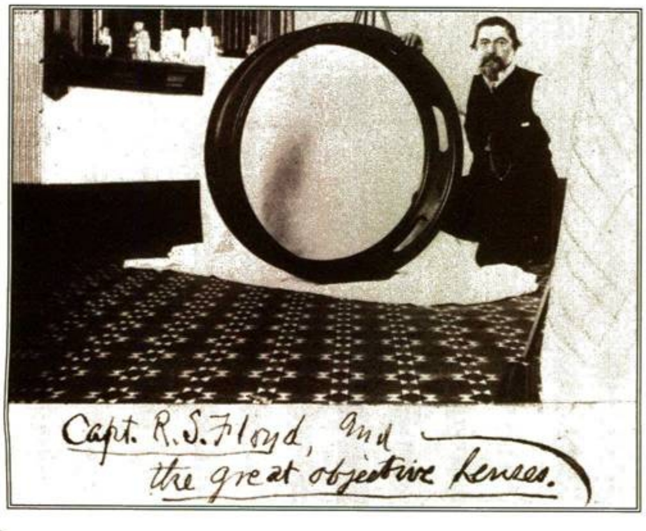


The bleary-eyed astronomer put away his dinner dishes, doused the fire, and prepared for the night's work. Sherburne Wesley Burnham, tired from camping in the wilderness fifty miles from San Francisco, was nearly ready to leave the isolated mountain peak where he had spent the last sixty days. As he looked down from the lofty summit, any signs of civilization in the valley below were lost beneath a summer fog that spilled through the Golden Gate and spread across the San Francisco Bay.

It was midsummer 1879, and Burnham had been sent to assess the qualities of the sky from Mount Hamilton, soon to be the home of the world's first mountaintop observatory. The observatory, founded by James Lick, a wealthy and eccentric San Franciscan, would open in the summer of 1888 with the world's largest telescope — a 36-inch refractor. The world's best telescopes at the time were located in Washington, Cambridge, Paris, and







Top left: The world's first mountaintop observatory, Lick Observatory would have been an unusual sight for travelers in nineteenth-century California.

Above: The observatory's large dome, here an unfinished superstructure, housed the world's largest telescope when completed in 1888.

Left: Winters could be harsh on Mount Hamilton, as this photograph of the astronomers' quarters shows.

Bottom: Lick's three-foot-diameter objective lens was the heart of the observatory's main instrument. Lick trustee Richard S. Floyd poses beside the lens.

Opposite page: On December 27, 1886, the 36-inch lens arrived on a horse-drawn stagecoach.

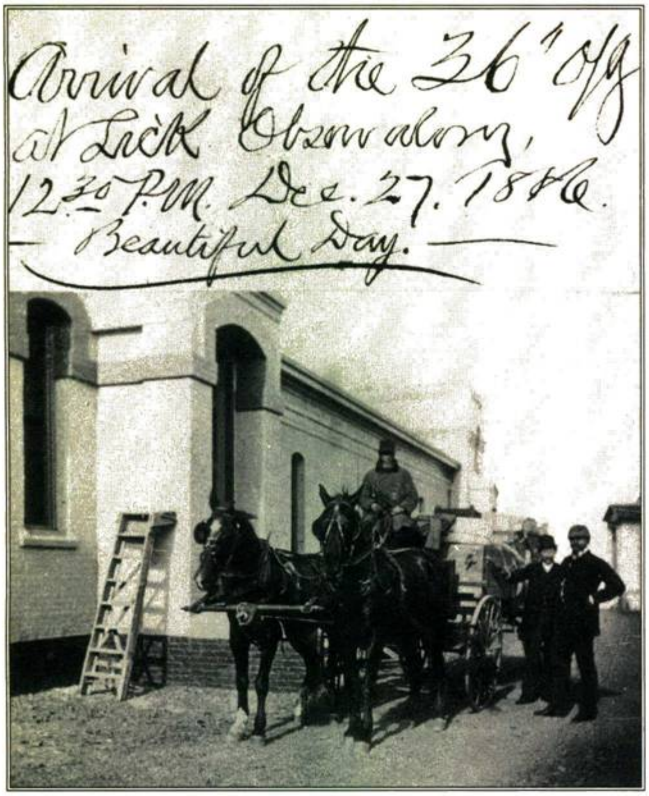
Photos courtesy of the Mary Lea Shane Archives, Lick Observatory; copyright University of California Regents.

Greenwich, and the largest was 26 inches. Lick's extraordinary telescope and the clear, steady skies of Mount Hamilton would put Lick Observatory at the forefront of astronomy.

Three men — Sherburne Burnham, Edward E. Barnard, and James E. Keeler — used Lick's resources to do trailblazing research during the observatory's early years. These astronomers would discover a new moon of Jupiter, study the nature of the planets better than ever before, classify thousands of stars, and probe the chemical properties of mysterious gaseous clouds in the sky.

The story of Lick Observatory begins with the California gold rush. James Lick arrived in San Francisco on the eve of the gold rush and through shrewd real estate ventures amassed a fortune during California's population boom before the Civil War. By 1873, when Lick suffered a stroke, he was worth over $3 million.

Without a family to leave his fortune to, Lick began to consider seriously how he would dispose of his wealth. Contacts Lick had made with several prominent scientists, including Joseph Henry, the secretary of the Smithsonian Institution, and Louis Agassiz, the famous Swiss-born naturalist, convinced Lick that he should build a lasting


Arrival of the 36" O/G
at Lick Observatory,
12 30 P.M. Dec. 27. 1886.
— Beautiful Day. —

scientific institution as a monument to his name.

Lick established a trust that provided for many projects. The largest chunk of money, $700,000, would go toward the construction of an observatory. Lick specified that the observatory would hold a telescope "superior to and more powerful" than any other. Lick's scientific advisors convinced him to build his observatory on a mountaintop, not in downtown San Francisco, as he had originally wanted. This was an unprecedented idea. Few astronomers then understood the advantages of mountaintop observing. For the sake of convenience, big telescopes had always been erected near a university or town in the lowlands.

In 1876, shortly after selecting Mount Hamilton as the observatory site, Lick died. He never saw his dream fulfilled. The work of building the observatory fell to Richard S. Floyd and Thomas Fraser, and the task facing the two men was immense. "The possibility that a complete astronomical establishment might one day be planted on [Mount Hamilton] seemed more like a fairy tale than a fact," wrote Floyd. "It was at that time a wilderness. A few cattle ranches occupied the valleys around it. Its slopes were covered with chaparral or thickets or scrub oak. Not even a trail led over it."

Building a Road to the Summit

In February 1876 Floyd and Fraser watched as a work crew built "Lick Avenue," a twenty-six-mile road to the mountain's summit. Six hundred men raced to finish the road before the next winter — blasting, grading, and spreading gravel. By December the road was finished.

But the road up the mountain brought an unexpected problem: squatters. In a letter to Floyd, Fraser described his effort to reclaim the observatory site in what he called the "Battle for Mount Hamilton."

"I took possession of Mount Hamilton . . . and built a house on the summit 8 x 12 with door and lock all complete. I had a very hard time getting the lumber up as the men had to carry it in a great many places. I have got 3 men in the house to defend it. There was a cabin built on the top [by the squatters] but I tore it down and set fire to it. I will have to keep three men till those that was squatters gives the thing up for a bad job. The squatters are over on the other side of the mountain and they might try to come back but they will soon leave I think as they will git starved out."

The next task was a thorough investigation of Mount Hamilton's sky conditions. Everyone suspected the sky would be clearer and darker on Mount Hamilton than in the lowlands, but the astronomers wanted to know how much better. To find out, Floyd hired Burnham, who was working in Chicago as a court reporter. Burnham, who had served with the Union Army as a shorthand reporter, had also developed a skill for which he gained international recognition. His keen eye and tireless energy, coupled with a 6-inch refractor purchased from the Alvan Clark firm, made him one of the best double star observers in the world.

In 1879 Burnham camped on Mount Hamilton for two months and tested the sky conditions with his 6-inch refractor. Burnham observed hundreds of double stars during his stay and discovered forty-two double stars. "If the proof is in the eating, these discoveries ought to be eloquent on the subject of Mount Hamilton for the site of an Observatory," Burnham wrote to Floyd.

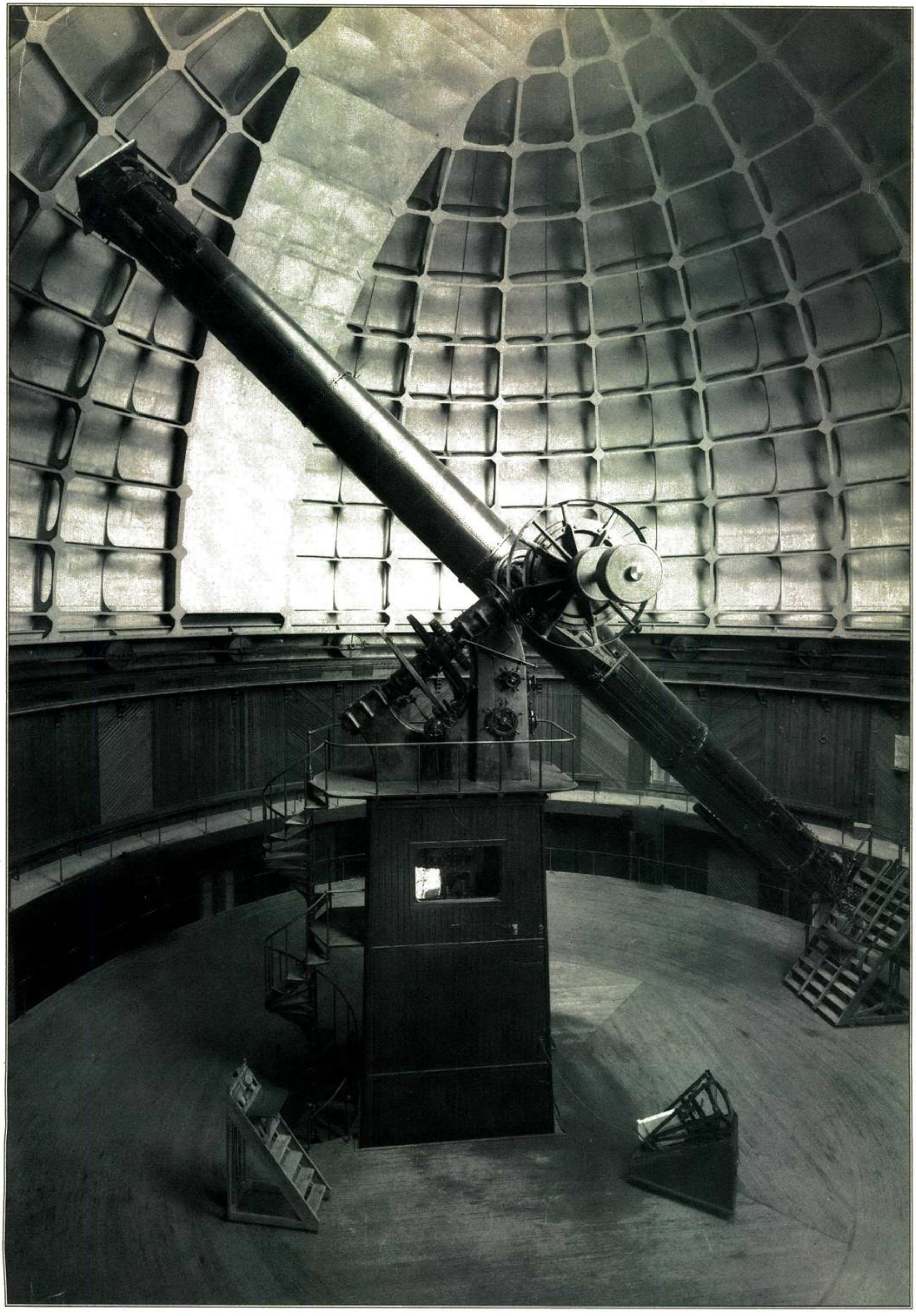
Satisfied with the unique conditions on Mount Hamilton, Floyd and Fraser's next task was to blow the top off the mountain so they could create a flat platform to hold the main observatory building, domes for the 12-inch and 36-inch telescopes, and several small buildings to serve as housing for a transit telescope, the observatory staff, and storage facilities. With a ton of black powder, Fraser and his work crew blasted free the topmost 70,000 tons of mountain and removed the rubble by hand. Then they raised a small building for a 4-inch transit telescope and began laying the foundation for a dome to house a 12-inch refractor.

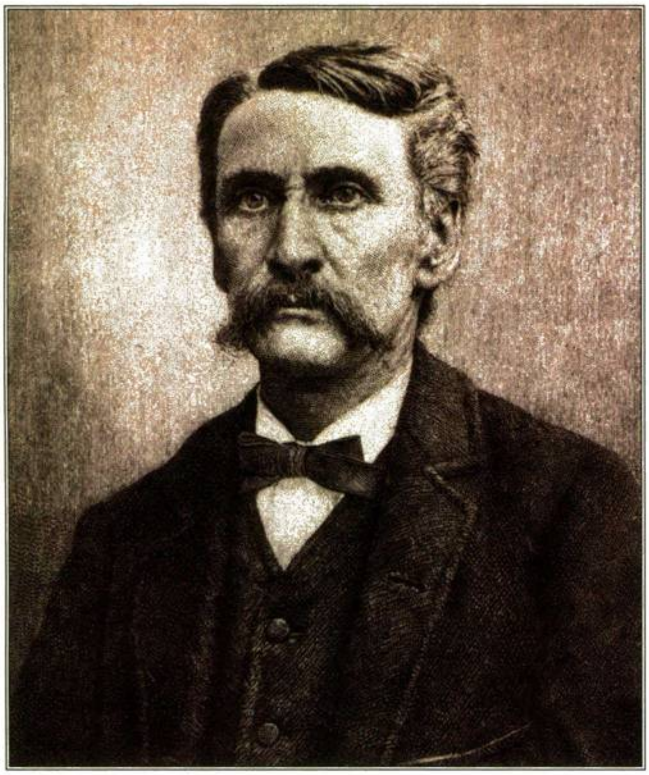
Lenses Travel Cross-Country

The 12-inch telescope was made by the Alvan Clark company, the premier telescope-making firm in America. The Clark firm would also painstakingly craft the objective lens for the 36-inch telescope in a process that lasted several years. By the autumn of 1886 the Clarks had completed the 36-inch lens in their Massachusetts workshop. Even though wintertime travel was risky, Fraser left on a journey to bring back the lens. Fraser and the Clarks packed the lens elements with meticulous care in steel boxes containing wooden boxes stuffed with curled hair to protect the valuable glass throughout the bumpy train ride.

Fraser and the lens traveled on a private car that was given special priority by the railroads. Other trains moved onto side tracks until the Lick Observatory car passed. After arriving in San Jose, Fraser hauled the lens by wagon to Mount Hamilton, and then Fraser and Floyd installed the lens in the metal cell that would attach to the telescope. They were assisted by a young, inventive astronomer named James E. Keeler.

Keeler had been hired by the Lick Trust specifically to provide scientific expertise as the observatory neared completion. The only university-trained scientist among the staff astronomers, Keeler was also a mechanical whiz. While in his teens, Keeler ordered a pair of lenses from an advertisement in *Scientific American* and with these





Above: Sherburne Wesley Burnham, a fifty-year old double star observer and court reporter from Chicago, was one of the original Lick staff astronomers. This engraving of Burnham was published in 1889.

Opposite page: Burnham used the 36-inch refractor to discover and catalog hundreds of double stars, a popular area of research at the time.

lenses built a small telescope. Keeler's father had operated a machine shop and forge and had taught Keeler to be a master tinkerer.

Keeler observed the sky as much as he could, keeping careful records and sketches along the way. A wealthy amateur astronomer who admired Keeler's skills sent him to Johns Hopkins University. Keeler graduated in 1881 with a specialized knowledge of spectroscopy. He went to Allegheny Observatory outside Pittsburgh as an assistant to Samuel P. Langley, one of the pioneers in the new branch of astronomy now called astrophysics. Langley impressed upon Keeler the value of using the latest technology to do research on the cutting edge of science.

On December 12, 1887, the last parts for the 36-inch telescope reached the mountain. Keeler and Floyd were among those there when the giant lens was installed in the 36-inch telescope.

Once the telescope was ready, the astronomers hoped for a clear night so they could see the "first light" through the world's largest telescope. Unfortunately their first chance, on December 31, 1887, was marred by one of the worst winter storms in decades. "We are all rather uncomfortable and short of blankets," wrote Floyd. The winds outside howled at speeds up to seventy miles per hour, creating drafts in the observatory and driving snow and freezing rain into every crack and crevice.

The storm raged for three nights until finally, on January 3, the sky cleared. The dome was impossible to turn — water had worked into the track and frozen solid — but with the shutter open the astronomers could see stars. They tried to observe the bright star Aldebaran, but they couldn't focus the telescope. The eyepiece drawtube was too long, which prevented an image from focusing on the eyepiece. After the astronomers cut off a piece of the drawtube, they focused on Aldebaran. Floyd called it "a blazing red sun."

Snow fell for several days, but the sky finally cleared on January 7. The dome was still frozen in one position. "We are all waiting in this office for Saturn to come by our shutter, which should be in about 2 hours," Floyd wrote in his logbook. When Saturn drifted into view, everyone wanted a look. Keeler described Saturn's image in the world's largest telescope as "the greatest telescope spectacle ever beheld by man. The giant planet, with its wonderful rings, its belt, its satellites, shone with a splendor never before equalled."

On June 1, 1888, Lick Observatory was turned over to the University of California to officially begin operations. Burnham joined the staff of Lick Observatory that year. His presence brought immediate prestige to the organization, just as the observatory's 36-inch refractor and unprecedented location brought instant fame to the mountain.

Also joining the staff was Edward Emerson Barnard. Barnard was so eager to work at Lick that he left his position at Vanderbilt University a year before the observatory opened. As a result, Barnard and his wife spent a year in San Francisco waiting for his position to start.

Barnard brought with him experience in a technique new to astronomy: photography. Barnard was a self-taught astronomer driven by a love of telescopes and of observing the sky. As a boy Barnard was forced to drop out of school to help support his family, but he found work in a photographic studio and rapidly learned the techniques of photography, which he later used in pioneering photography of the Milky Way Galaxy.

As soon as he could, Barnard bought a telescope for $380, two thirds of his annual salary. In 1881 he discovered a comet, the first of twenty he found in his career. Barnard's observing abilities also won him a fellowship at Vanderbilt University. Using Vanderbilt's 6-inch refractor, Barnard demonstrated his keen eyesight one night as he watched the Moon occult the star Beta Capricorni. Because the Moon has no atmosphere, he reckoned, the star should "blink off" instantaneously as it passed behind the Moon's limb. But Barnard thought it took seven tenths of a second to flicker out. He had discovered that Beta Capricorni is a double star, the seven tenths-second delay was caused by the companion star's occultation. The discovery was confirmed by Burnham, who was then at Dearborn Observatory in Chicago.

Life on the Mountain

This collection of astronomers from the East didn't have an easy time during the early years at Lick. Living conditions on Mount Hamilton were primitive and cramped, and there was little to do for recreation. At fifty years of age, Burnham was an informal, folksy man with a reputation for his keen eye and clear mind. He came to Mount Hamilton with his wife and children, who received inadequate housing and no schooling. Keeler, very different from Burnham, was a serious thirty-one-year-old bachelor with an impressive education. Barnard, also thirty-one, was hard-driving and highly neurotic.

Lick Observatory's initial research program, as out-

Above: At Lick Edward Emerson Barnard photographed the sky with a passion and discovered Jupiter's fifth moon in 1892.

Right: One of Barnard's interests at Lick was photographing the Milky Way. Barnard's exposures show thousands of stars, gas clouds, and pockets of dust along the Galaxy.

lined by its first director Edward S. Holden, included four major areas. Double star research, Burnham's specialty, was of long-standing interest in the nineteenth century. Discovering and cataloging pairs so future astronomers could study the orbits of these pairs were prerequisites for an observatory at the time. Astrometry — measuring star positions — was valuable for studying the overall distribution of stars across the sky. Holden also wanted to make an accurate photographic atlas of the Moon.

But the innovative technological research lay in the fields of spectroscopy and photography. Spectroscopy allows astronomers to study the component colors in a star's light and determine certain properties about the star. Although Isaac Newton had discovered that a prism disperses light into a rainbow of colors in the 1700s, work on classifying stars by spectra was crude throughout most of the 1800s.

Photography was invented in the 1830s, but the emulsions that were used remained far too insensitive for astronomy until the 1880s. Several astronomers had made long-exposure photographs of the Sun and Moon, but even most of the brightest stars were out of the range of this technique. Observations had to be written or sketched in notebooks. However, more sensitive emulsions made photography a certain tool for the future of astronomy in the 1880s. Barnard had extensive photographic experience and would undertake influential experiments with photography.

Probing the Stars

Spectroscopy was pioneered at Lick Observatory, and Holden had recruited Keeler primarily for his expertise in this field. With the world's largest telescope and a specially designed spectroscope at his disposal, Keeler became the leading spectroscopist in the world. The spectroscope created a spectrum that Keeler could examine visually. Keeler began the work of recording the spectra of stars and cataloging this information, which was the most important contribution to science in the observatory's early history and would lay the groundwork for understanding the types of stars in the Galaxy.

Stars were not understood well in 1888. Twenty years before, Italian astronomer Angelo Sechi divided stars into four classes, based on early, crude inspections of spectra. Astronomers knew stars had different brightnesses and temperatures. They also had a rough conception of the disk of stars that is the Milky Way. However, a great deal of basic research on the spectra of stars and stellar motions relative to Earth had to be done to produce a picture of what stars and the Galaxy are like.

One primary field of spectroscopic research was

measuring radial velocities of stars. Holden gave Keeler two nights per week on the 36-inch telescope for this work, because the director considered measuring radial velocities of stars "the principal spectroscopic work for which the great telescope was designed." Keeler's measurements would enable astronomers to determine the solar system's motion with respect to nearby stars and would prove the first step in a march to map out the motions of stars in the Milky Way. This in turn led to a better understanding of our Galaxy's contents, size, and dynamics.

As the work progressed, Keeler observed several stars bright enough for him to measure the Doppler shift created by their radial motion in their spectra. He shined an iron arc lamp into the spectroscope and used the micrometer to measure the positions of the star's spectral marks relative to the known wavelengths produced by the arc lamp.

But Keeler was also intrigued by nebulae and turned his spectroscope on these objects to help settle a long-festering argument. At the time a debate raged among astronomers regarding the widths and wavelengths of the strongest lines visible in the spectra of nebulae. Keeler, aided by the powerful Lick telescope, the quality of his spectroscope, and the sharp images on Mount Hamilton, helped resolve this debate by showing distinct spectral lines. Because of Keeler's work astronomers soon had better understanding of the chemical properties of nebulae.

While Keeler produced more and more of the world's finest spectra, Barnard pioneered celestial photography. "There is no doubt but that [photography] is *the* Astronomy of the future," he wrote. The ease with which Barnard accepted photography's growing role in astronomy undoubtedly resulted from his twenty years of experience in photography. Holden relied on Barnard to develop the series of photographic plates he was taking to create an atlas of the Moon, the director's major research undertaking.

The Beginning of Astrophotography

Barnard first made a camera from a wooden box that held a 6-inch wide-field lens and a photographic plate. The box was strapped onto the side of a 6-inch refractor he used for guiding the photographs. "[W]ith only the rudest equipment," Barnard began photographing comets. He was amazed at the results and later wrote: "It appears that there is now some hope of tracing [a comet] from day to day by photographic means, and of obtaining in this way some clue to the energy of the forces which produce [the] observed changes."

The power of a wide-field lens coupled with a photographic plate was fully demonstrated when Barnard turned his celestial camera toward the Milky Way. Barnard's photos, "the only photographs ever made, here or elsewhere, that show at all the true Milky Way," as he characterized them, revealed "vast and wonderful cloud forms, with all their remarkable structure of lanes, holes, and black gaps and sprays of stars."

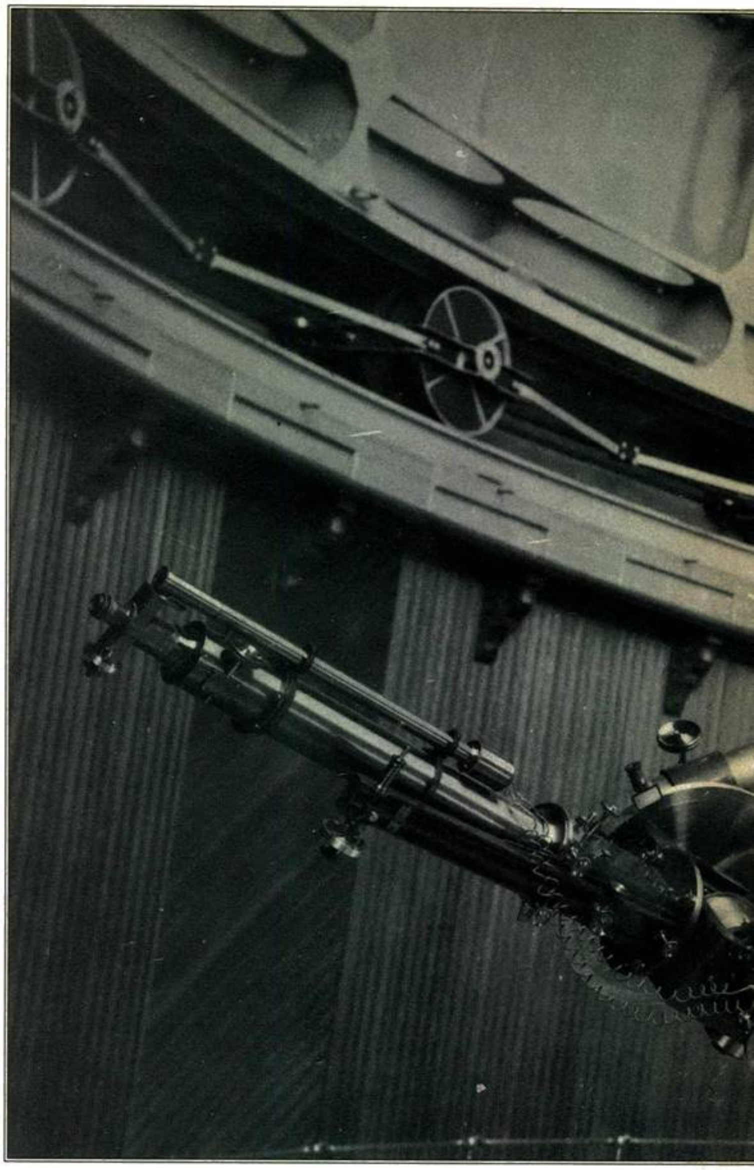
Barnard's photographs showed structures along the Milky Way never before seen and sent a wave of excitement through the world of astronomy. They also showed known structures and nebulae in better detail than ever before. Although the photographs weren't instantly used as data, they pointed the way toward an increasingly important role for photography in the future of astronomical research.

Burnham continued discovering and cataloging double stars, including 198 new pairs discovered with the 36-inch telescope and 56 more with the 12-inch refractor. The information Burnham gathered about these stars — magnitudes, positions, position angles, and colors of the members in double star systems — would be used by astronomers after Burnham's time to determine how double stars orbit each other and how they are distributed throughout the Galaxy.

John Schaeberle was assigned the task of measuring star positions. A quiet bachelor, Schaeberle was well suited to Mount Hamilton's isolation and working alone with the 4-inch transit instrument. To determine stellar positions, Schaeberle watched the stars passing through the view of the transit telescope and timed their passage with a clock. This gave him the exact time the star passed directly overhead and by calculation the star's position relative to other stars.

Can You See the Martian Canals?

Although the staff members had their own areas of research, some subjects attracted all of them. Mars in particular was a hot topic at the end of the nineteenth century. The popular press, fueled by news from Italian astronomer Giovanni Schiaparelli, reported signs of intelligent life on the Red Planet. This was largely based on Schiaparelli's observations of "canals," or straight, fine



Above: James E. Keeler became interested in spectroscopy while at Johns Hopkins University. Always trying to "push technology to the limit," Keeler knew this new technique would become a powerful astronomical tool.

Right: Keeler used this spectroscope to record the spectra of stars, planets, and nebulae.

markings on the planet's surface. The Lick astronomers were eager to see if the 36-inch scope would reveal these markings.

On one evening Schaeberle claimed to see Martian canals and described them as twin, parallel tracks. Keeler, however, observed the planet along with Schaeberle and saw only faint markings, not thin lines. Barnard, who had exceptional eyesight, also reported seeing only faint splotchy markings without significant patterns.

Barnard and Keeler, those with the most experience, were extremely skeptical. The problem in resolving this debate was that the detail on the planet's surface was so subtle it was impossible to see distinctly, which left the nature of this detail open for interpretation. The debate would only be resolved years later, when much larger telescopes provided a clearer view of Martian surface details.

In 1888 astronomers were also trying to understand the outer planets. Astronomers knew a great deal about the orbits and masses of these planets but not much about their atmospheres and compositions. Uranus and Neptune were faint enough to make studying them very difficult. Jupiter and Saturn were relatively bright, but spectroscopy was primitive and no one had the expertise to use it to its full advantage until Keeler began using the 36-inch telescope.

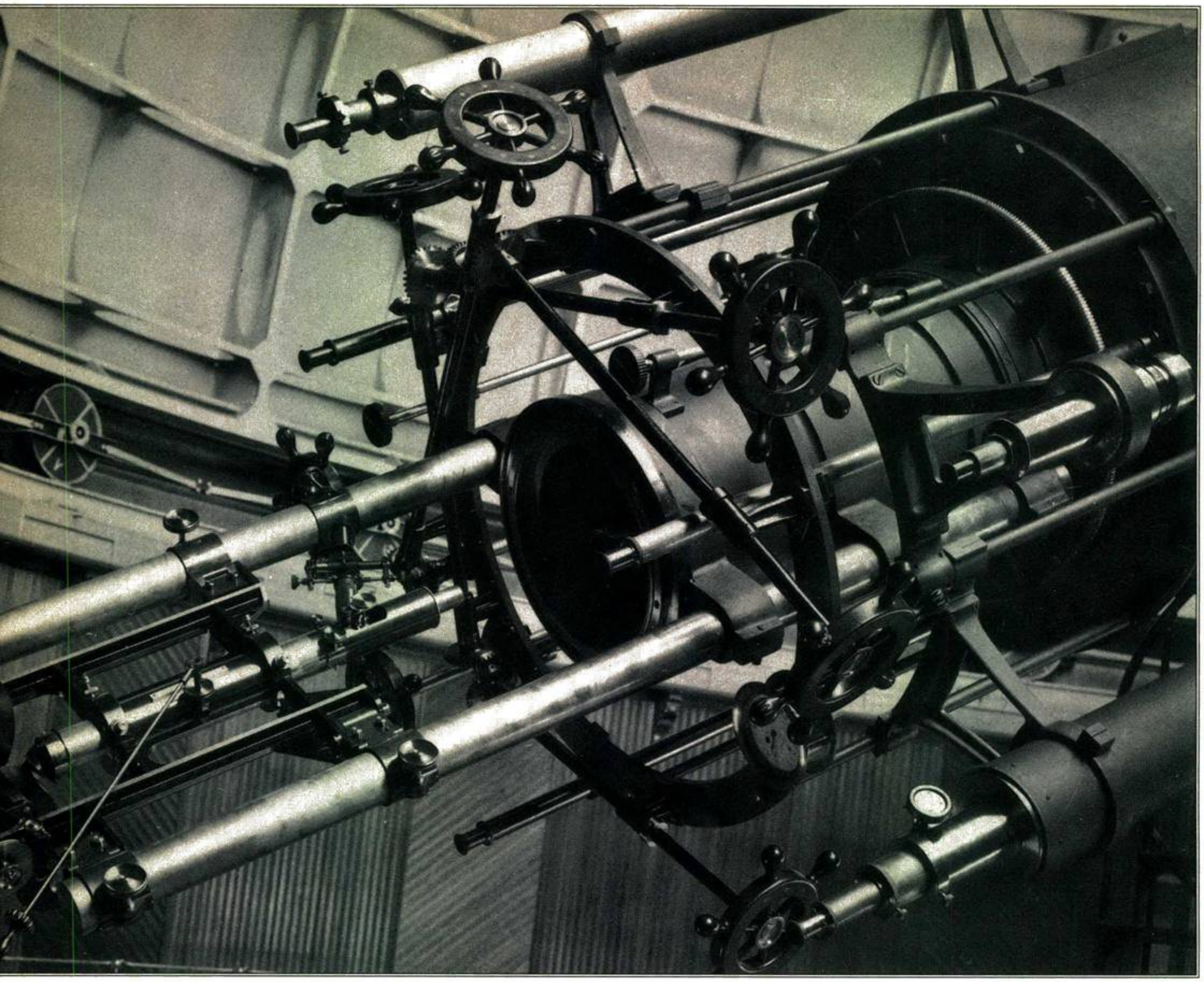
With his spectroscope Keeler extensively studied Saturn, Jupiter, Uranus, and Neptune. In all these planets he saw broad absorption bands now known to be caused by methane. At the time some astronomers believed the outer planets were self-luminous, but Keeler's research supported the notion that they shine by reflected sunlight.

Another question that fascinated astronomers of the time was the nature of Saturn's rings. Using the 12-inch refractor, Barnard observed an eclipse of one of Saturn's moons, Iapetus. When Iapetus passed behind the planet's rings, Barnard could see the moon shining faintly through the outer ring. This proved the ring was partially transparent and offered an important clue to the nature of the rings.

A Fifth Moon for Jupiter

Soon after Barnard gained access to the 36-inch telescope, he made a major discovery. One night while observing Jupiter, Barnard noticed an extremely faint dot of light in the same field of view as Jupiter. He followed the faint light for several hours and on the next night saw it again. On September 9, 1892, Barnard realized he had discovered a fifth moon of Jupiter, which was later called Amalthea.

This discovery made Barnard a national celebrity: he was described in newspapers as "the greatest astronomer of all time." In subsequent years several more Jovian moons were discovered by Lick astronomers, but none caused the excitement generated by Barnard's discovery of Amalthea.



This discovery marked the high point of the early days at Lick Observatory. By that time the first group of pioneer astronomers had begun to move on to other observatories and fields. In 1890 Keeler left to get married and start a family. He returned to Allegheny Observatory in Pittsburgh, where he replaced Langley as director. There he continued to advance spectroscopy and proved that Saturn's rings are composed of countless small particles. In 1898 Keeler came back to California as Lick's second director. As director Keeler photographed hundreds of nebulae unknown before his time and established the existence of the spiral structure in some nebulae that would later be called galaxies.

After four years at Lick, Burnham returned to a courtroom job in Chicago. In Illinois Burnham kept up with astronomy and later joined the staff of Yerkes Observatory in Wisconsin. Barnard stayed at Lick until 1895 when he joined Burnham at Yerkes. Barnard continued experiments with photography and produced a series of extraordinary Milky Way photographs that showed astronomers the complex arrangement of the Galaxy for the first time.

Although the early astronomers at Lick Observatory left and went on to great careers elsewhere, great things continued to happen at Lick. Heber D. Curtis extended Keeler's work by pushing forth the understanding that spiral nebulae are galaxies. Robert Grant Aitken followed in Burnham's tracks — discovering, cataloging, and studying thousands of double stars. William W. Campbell organized many solar eclipse expeditions that led to associate Robert J. Trumpler's confirmation of the general theory of relativity. Trumpler's studies of stars in clusters led to the discovery that dark matter absorbs light in space, one of the most important new ideas of twentieth century astronomy.

Lick Observatory has left a major imprint on modern astronomy. When it was founded in 1888, it was the world's first mountaintop observatory and housed the world's largest telescope. And fortunately for astronomical knowledge, three of the era's greatest astronomers, Barnard, Burnham, and Keeler, spent busy, productive years at Lick. The discoveries they made and the work they did there serve as a powerful reminder of the American pioneer spirit.

John R. Gustafson handles public relations for the California Association for Research in Astronomy, the operators of the W. M. Keck Observatory. Formerly a staff member at Lick Observatory, he is coauthor of Eye on the Sky: Lick Observatory's First Century, *published this spring by the University of California Press.*

ASTRONOMY Reader Poll Results

SHAPING AMERICA'S FUTURE IN SPACE

Readers want to see the United States cooperate with other nations, not another space race, and they ranked manned missions NASA's number one priority for the future.

The Soviet Union's current lead over the United States in space exploration and technology worries almost half of the ASTRONOMY readers who responded to our Reader Poll, "Deciding America's Future in Space," which appeared in the January 1988 issue. But many readers felt that international cooperation, not increased competition, was the key to the future of space exploration.

The top priority of America's space program was manned space flight, according to 32 percent of the 2,250 readers responding to our poll. Following closely behind manned missions was solar system exploration, which was supported by 28 percent. Orbiting observatories were supported by 20 percent, advanced space flight vehicles by 13 percent, and "other" priorities including the Space Station and manned bases on the Moon and Mars by 7 percent.

Top Priority: Manned Missions

QUESTION: What aspect of our space program would you like to see as NASA's dominant focus in the future?

#1	Manned space flight	32%
#2	Solar system exploration	28%
#3	Orbiting observatories	20%
#4	Advanced space flight vehicles	13%
#5	Other	7%

Readers' comments explained why manned missions received such strong support. "The exploration of space is important for the education and technology of America," wrote Steven Russo of Auburn, New York. "Regardless of cost, be it money or lives, this exploration of the cosmos must continue, and it must continue with manned spaceflight."

"The American people will want to ride along on any space program. If you do not take the public along (via manned spaceflight), it will lose interest," wrote K. W. Warns of Sioux Falls, South Dakota.

"The challenges, excitement, and great rewards of our efforts in the 1960s can and should be rekindled in an even more ambitious program of manned spaceflight," wrote Robert H. Holder of Austin, Texas.

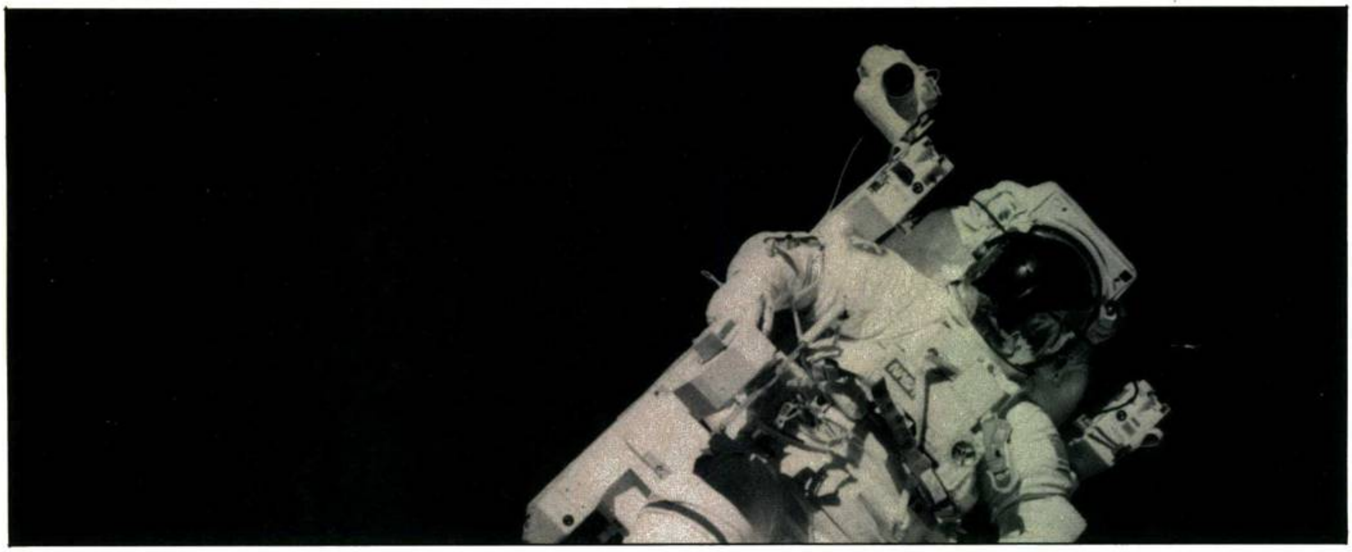
In response to our question about whether the United States should pursue manned expeditions to other bodies in the solar system, 93 percent of the readers said yes. When asked if they'd support a permanent manned base on the Moon, 92 percent said yes, and when asked if they'd support manned exploration of Mars, 90 percent said yes. The answers to these three questions corresponded to the number one priority readers gave manned missions in the question on NASA's dominant focus in the future.

What's significant about the reader responses to the three specific questions about manned expeditions is that there wasn't a "Moon versus Mars" debate. Though readers overwhelmingly favored manned missions, they didn't indicate a strong preference for manned missions to Mars or a manned outpost on the Moon but were almost equally in favor of both.

When asked what area of the solar system NASA should explore further if sufficient funds were not available for a balanced program of exploration, 65 percent said the inner solar system, 28 percent said the outer solar system, and 7 percent said primitive bodies.

Many readers put unmanned exploration of the solar system ahead of manned exploration because robotic missions would be less expensive than manned missions. "Manned space travel seems inevitable and should be pursued, but unmanned probes provide a great deal of information at a fraction of the cost," wrote John van Moort of Burnet, Texas. "Let's concentrate on aggressive unmanned exploration as a first priority."

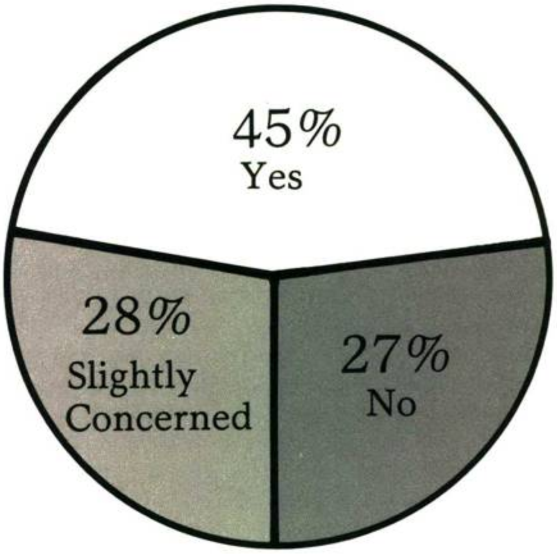
The poll did not uncover an overwhelming concern



NASA Photo

Soviet Space Threat: Mixed Emotions

QUESTION: Are you worried about the Soviet Union's apparent lead over the United States in several areas of space exploration?



about the Soviet lead in space. When asked to rate how they felt about recent Soviet advances, 45 percent said they were worried, 28 percent said they were slightly concerned, and 27 percent said they were not worried.

Surprisingly, although the poll did not address international cooperation in space, the issue was raised by many readers. Over 10 percent felt strongly enough about the subject to state in their write-in comments that space exploration should be a cooperative venture.

"These explorations are part of the beginning of an era in human history, not a sporting event. We should stop encouraging the media's treatment of them as competitions where whoever is first, wins," wrote Arthur Farah of Flint, Michigan.

"We should earnestly develop an ongoing, long-range joint venture, not only with the European and Japanese space agencies but with the Soviet Union as well," wrote Tony Ristakian of Massapequa Park, New York. "Why not share the expense, work, and danger with all mankind?" wrote John Cindrich of Mission, Kansas. "After all, looking at Earth from the surface of Mars, there are no borders, boundaries, or countries."

"If we begin by being interdependent up there, who knows, it may start a trend back on Earth," wrote Dora Yen of Pacifica, California. "I would like to see all 'national' space programs scrapped! Meaningful space exploration is impossible for one nation alone. Let's beat those swords into space vehicles!" wrote Rod Joblove of Dayton, Ohio.

"I'd prefer the United States to be the leader, but space exploration is more important than regional differences," wrote Patrick O'Connor of Chicago, Illinois.

Several readers pointed out that international ventures would be more economical than national ones. "The overall cost of space exploration must require an outlay greater than any single country can possibly bear alone," wrote Frank Daly of Rutherglen, Scotland.

"It's financially foolish as well as egocentric for the United States to believe it has the sole mandate to 'conquer space.' NASA needs the cooperation of all spacefaring nations," wrote Shirley Fowley of Waterloo, Ontario.

A competitive outlook on space was also replaced by a concern for the quality of America's future space program. "I hope in the future NASA will try to be the best, not necessarily the first," wrote Linda Cypert of Sandwich, Illinois. "We need to learn to seek knowledge because of the rewards of having that knowledge, not just to beat someone else," wrote Jim S. Egger, of Palmer, Alaska.

"I am less concerned about the apparent Soviet lead in space technology than about the apparent lack of U.S. advances in these areas," wrote Jennifer Broekman of Floral Park, New York.

In addition to support of manned missions and international cooperation, readers' comments overall supported a strong American space program. (See In Focus on page 38 for additional comments.) But along with optimism for the future, readers expressed frustration over the current halt in U.S. space activities. As Bernard Simoneit of Corvallis, Oregon, put it: "Let's get back out there before it's too late."

— *Kristine R. Majdacic*

RADIO ASTRONOMY LOOKS TO SPACE

The future of radio astronomy lies in space-based telescopes beyond the confines of Earth.

By Kurt W. Weiler, Brian K. Dennison, and Kenneth J. Johnston

Pulsars, stars crushed by the force of gravity to spheres only a few miles across that rotate several times each second; quasars, enigmatic objects barely the size of our solar system that generate as much energy as a hundred galaxies; the 3-degree background radiation, the faint relic of a tremendous explosion that occurred some 20 billion years ago and gave birth to our universe — these are just three of the most significant discoveries made by radio astronomers. But while present instruments continue to make great strides, this traditionally ground-based science has reached the limits of what can be done from Earth's surface.

Three specific problems plague radio astronomers trying to expand their study of the universe. The lowest-frequency radio waves, those with wavelengths in the 10- to 100-meter range, can't penetrate Earth's ionosphere and are bounced uselessly back into space. In addition, the technology for high-frequency observations in the millimeter- and submillimeter-wavelength range has advanced to the point where the atmosphere is a significant limitation.

Finally, in a very real sense the size of our planet is a limitation. Radio astronomers have developed instruments known as interferometers and techniques such as very long baseline interferometry (VLBI) to link their individually "small" radio antennas together into cooperative networks, which form telescopes that are effectively miles, hundreds of miles, or even thousands of miles in diameter. The great size of these arrays allows radio astronomers to see very fine details in images of radio sources. However, the sizes of VLBI networks already have grown to the diameter of Earth.

For these reasons radio astronomers are on the verge of expanding their instruments into space. By escaping the physical boundaries imposed by Earth and opening the last unexplored regions of the electromagnetic spectrum, radio astronomers hope to continue their role at the forefront of astronomy.

Exploring the Unexplored

At frequencies lower than about 20 million hertz (a wavelength of 15 meters) celestial radiation is absorbed and reflected by Earth's ionosphere. Although the ionosphere is useful in Earth-based communications — AM radio signals bounce off it and therefore travel farther than would be possible otherwise — it prevents low-frequency radiation originating outside the ionosphere from reaching Earth's surface. Thus, the universe at very low frequencies is virtually unexplored.

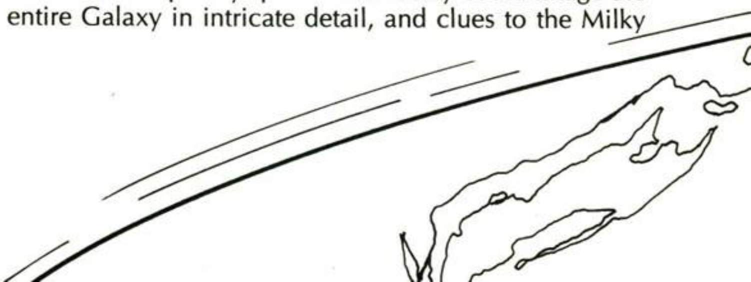
Our picture of the universe at low frequencies should be very different from the one we already know. Frequencies of about 1 million hertz (300 meters) — the limit beyond which our entire Galaxy begins to block the radiation — are as far removed from normal radio astronomy frequencies as normal radio astronomy is from the infrared, infrared is from the ultraviolet, and ultraviolet is from x-rays. Every time astronomers open a new window on the universe, we make major discoveries and gain significant insights into the nature of the universe.

For example, the Einstein x-ray satellite opened up a whole new, unexpected "hot" universe of million-degree temperatures, violently interacting stars, and extreme activity in the centers of galaxies and quasars. At the other end of the temperature scale the very successful Infrared Astronomical Satellite probed the "cold" matter in the universe just a few degrees above absolute zero, where only a feeble warmth is radiated by newborn stars swaddled in thick clouds of gas and dust. A low-frequency radio astronomy telescope in space would likewise chart new territory, and the likelihood of discovering unexpected new physical processes and objects would be great.

The Lowdown on Low Frequencies

The radio emission from our own Galaxy, the Milky Way, has always been an extremely fruitful area of research. In fact, the first observations of radio radiation from beyond Earth were of the Milky Way, and they were made at low frequencies. In 1932 Karl Jansky, working at Bell Laboratories, realized some of the static he was receiving originated in the Galaxy and that the strongest component of that emission came from the galactic center. The emission arose from charged particles accelerated by magnetic fields to a speed near that of light and was the first evidence that the Galaxy contained a new type of radiation — synchrotron radiation.

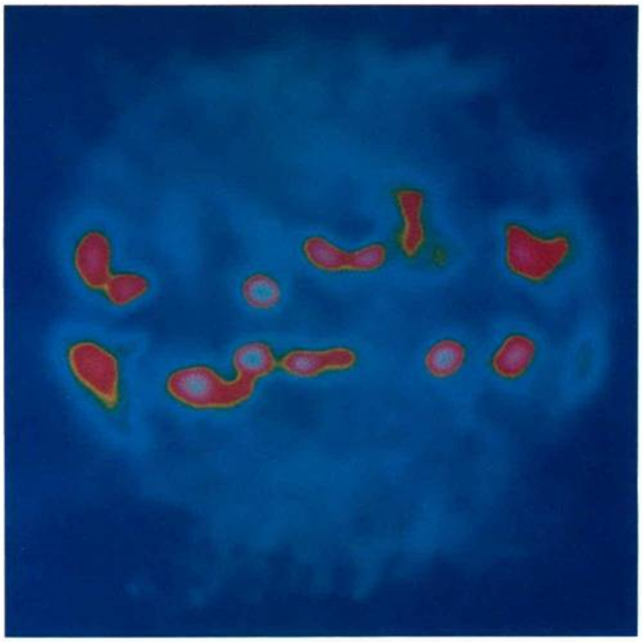
A low-frequency space observatory could image the entire Galaxy in intricate detail, and clues to the Milky



Way's structure and evolution would be revealed as never before. For example, such an observatory could investigate the origin of the mysterious and ubiquitous cosmic rays or help astronomers understand the large, looplike structures that appear to stick out of the galactic plane. Are these loops leftover effects from nearby supernovae that occurred many thousands of years ago, or are they instead "leaks" in the Galaxy's magnetic field?

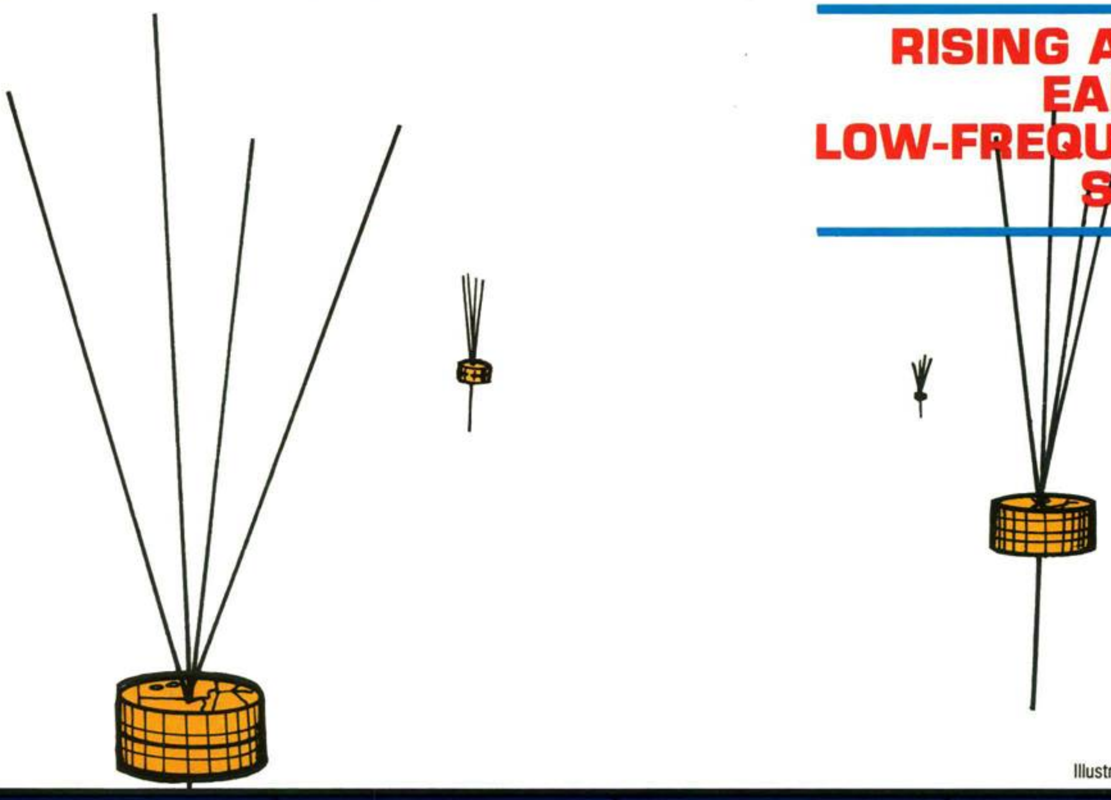
Astronomers have argued for over thirty years about whether our Galaxy is surrounded by a large "halo" of particles and magnetic fields that is too faint to detect with normal observations. Theoretical models predict that such a halo is needed to keep the Milky Way in the shape of a flattened disk. A low-frequency telescope could investigate this question and reveal many of the properties of the halo if it does exist, as well as extend the search to other galaxies.

Outside of our Galaxy, very little is known about the low-frequency behavior of distant radio sources. Do the sources change as their distances from us increase? If so, the universe is not the same now as it used to be, because light from more distant objects travels farther to reach us and thus reveals the objects as they were at a younger age. What new types of radio sources are visible only at very low frequencies? What "fossils" of bygone eons can we detect by probing the low-frequency radiation emit-



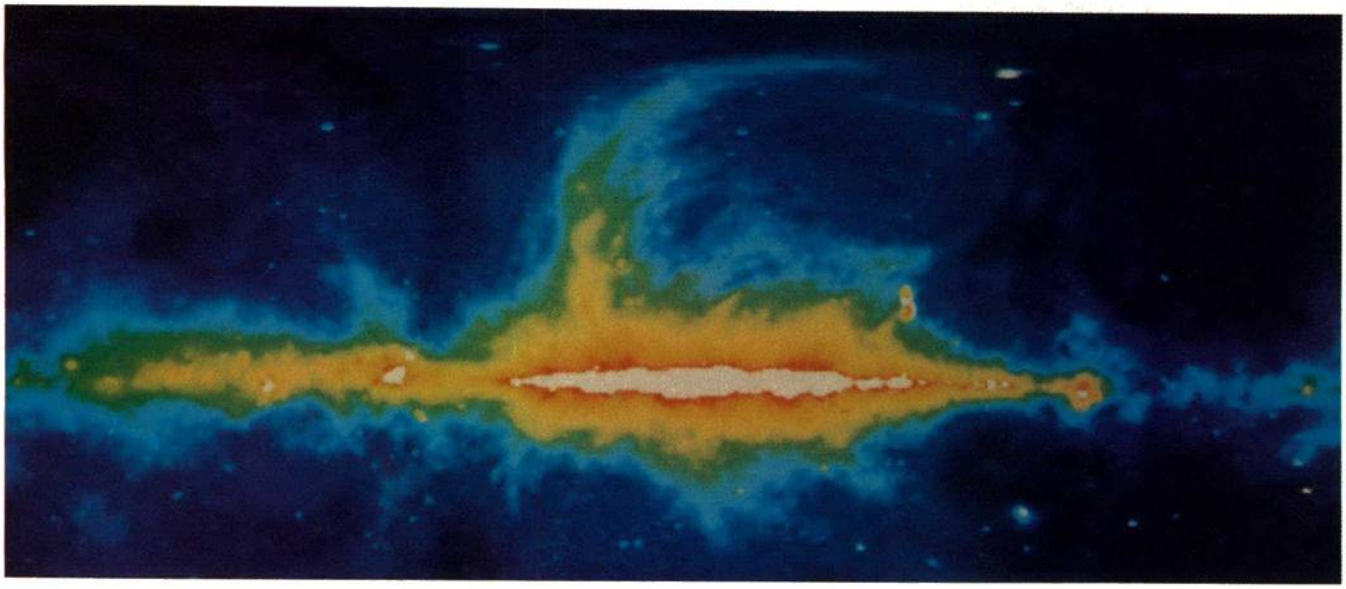
The Sun should be a very strong source of low-frequency radio radiation. It will also serve as the bench mark for high-resolution studies of other stars. Radio image of Sun courtesy NRAO.

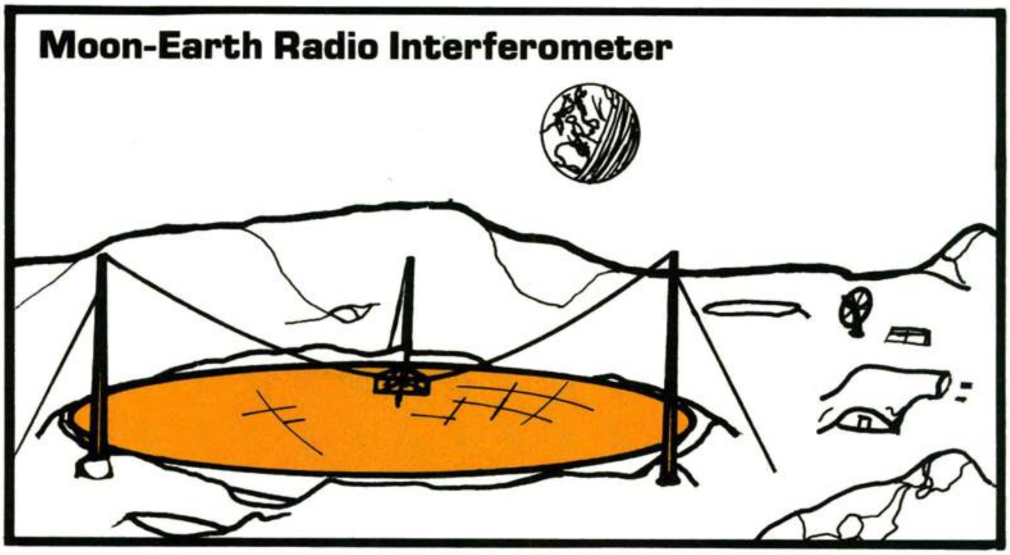
RISING ABOVE EARTH'S LOW-FREQUENCY SHIELD



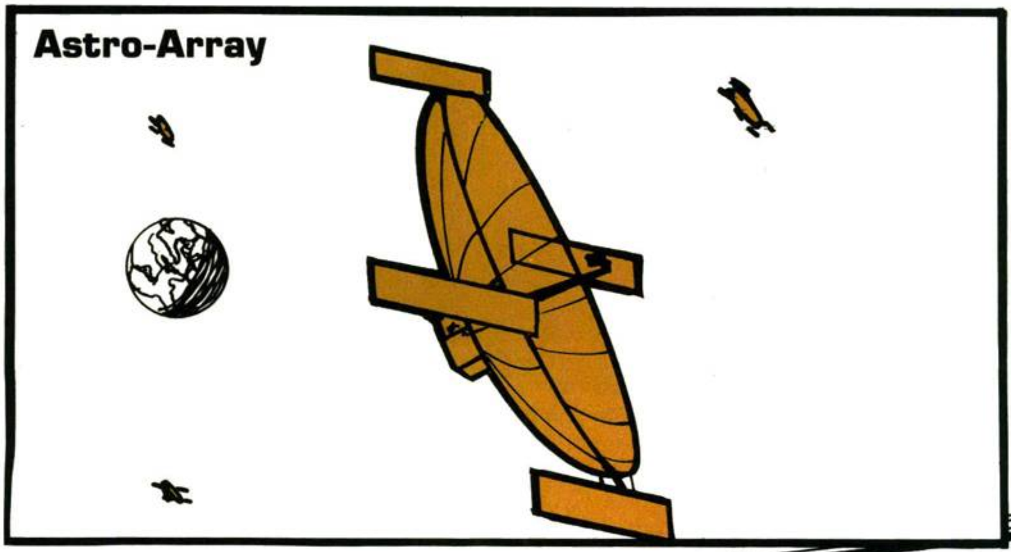
Illustrations by Tom Hunt

Nature of Problem	Project Name	Project Specifications	Prime Observing Goals
Earth's ionosphere absorbs and reflects low-frequency radio radiation.	Low Frequency Space Array (LFSA)	Each of the four antennas has arms 85 meters long and circles Earth in an orbit with a radius of 6,000 miles. Total array size varies from less than 1 mile to nearly 200 miles.	Milky Way Galaxy; millisecond pulsars; extragalactic radio sources; supernova remnants; Sun; Jupiter





Moon-Earth Radio Interferometer



Astro-Array

Left: The Milky Way will be a target for all space-based radio observatories. High-resolution studies of the galactic center may reveal the nature of the energy source located there. Image courtesy C. Haslam, Max Planck Institute for Radio Astronomy.

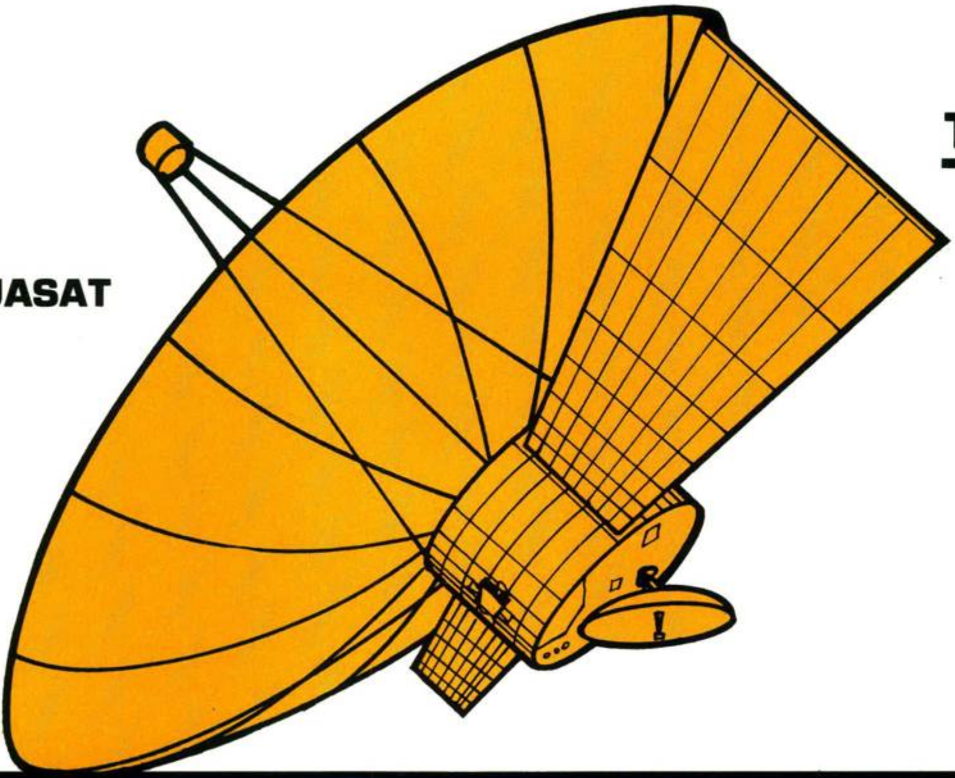
ted by electrons and magnetic fields that have much lower energies now than when the radio source was younger? And what did the radio sky look like a few billion years ago? A sensitive low-frequency instrument in space could study thousands of distant radio sources in great detail and would go a long way toward answering these questions.

The brightest low-frequency sources in the sky should be the incredible millisecond pulsars — neutron stars that rotate a thousand times each second — and large, gaseous systems emitting coherent radiation. The pulses of radiation emitted by millisecond pulsars occur at such precise intervals that these objects make excellent clocks — more accurate than any Earth-based clock. In addition to improving time keeping on Earth, these pulsars can probe the dynamics of the systems to which they belong. Unfortunately, millisecond pulsars are difficult to find with current technology because they are faint and have such short periods that supercomputers are needed to interpret the observational data. With a low-frequency radio telescope, millisecond pulsars will be bright enough to see easily, and so many more members of this intriguing class of objects will be found.

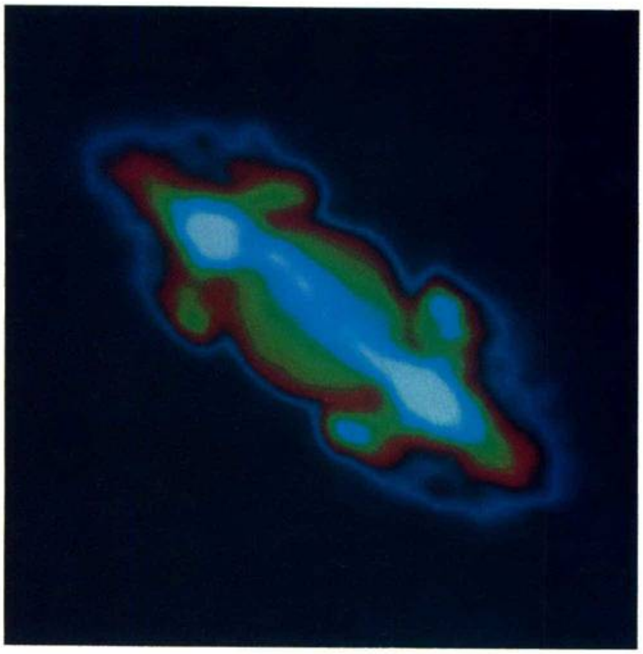
Many other objects in our solar system, particularly the Sun and the planets, will be brilliant and violently bursting sources of low-frequency radio waves. A low-

BASELINES LARGER THAN EARTH

QUASAT



Nature of Problem	Project Name	Project Specifications	Prime Observing Goals
High-resolution radio astronomy requires interferometers with long baselines; present day interferometers are already as large as Earth.	QUASAT	A 15-meter-diameter radio telescope in an elliptical orbit 15,000 miles from Earth that works in conjunction with major VLBI networks on the ground.	Inner regions of quasars and active galaxies; central region of Milky Way; radio stars; masers; supernovae; giant planets; determine accurate positions and motions of objects out to the Virgo Cluster
	Astro-Array	An entirely space-based array of thirty 50-meter-diameter radio telescopes in orbits with a radius of 60,000 miles.	
	Moon-Earth Radio Interferometer (MERI)	An interferometer linking radio telescopes on the Moon, Earth, and in space to form a baseline up to 250,000 miles in diameter.	



Left: A high-frequency radio telescope will open a new window on the solar system. Among other things, such an instrument will be able to measure the composition and dynamics of planetary atmospheres. This radio image shows huge radiation belts surrounding the circular disk of Jupiter. Courtesy NRAO.

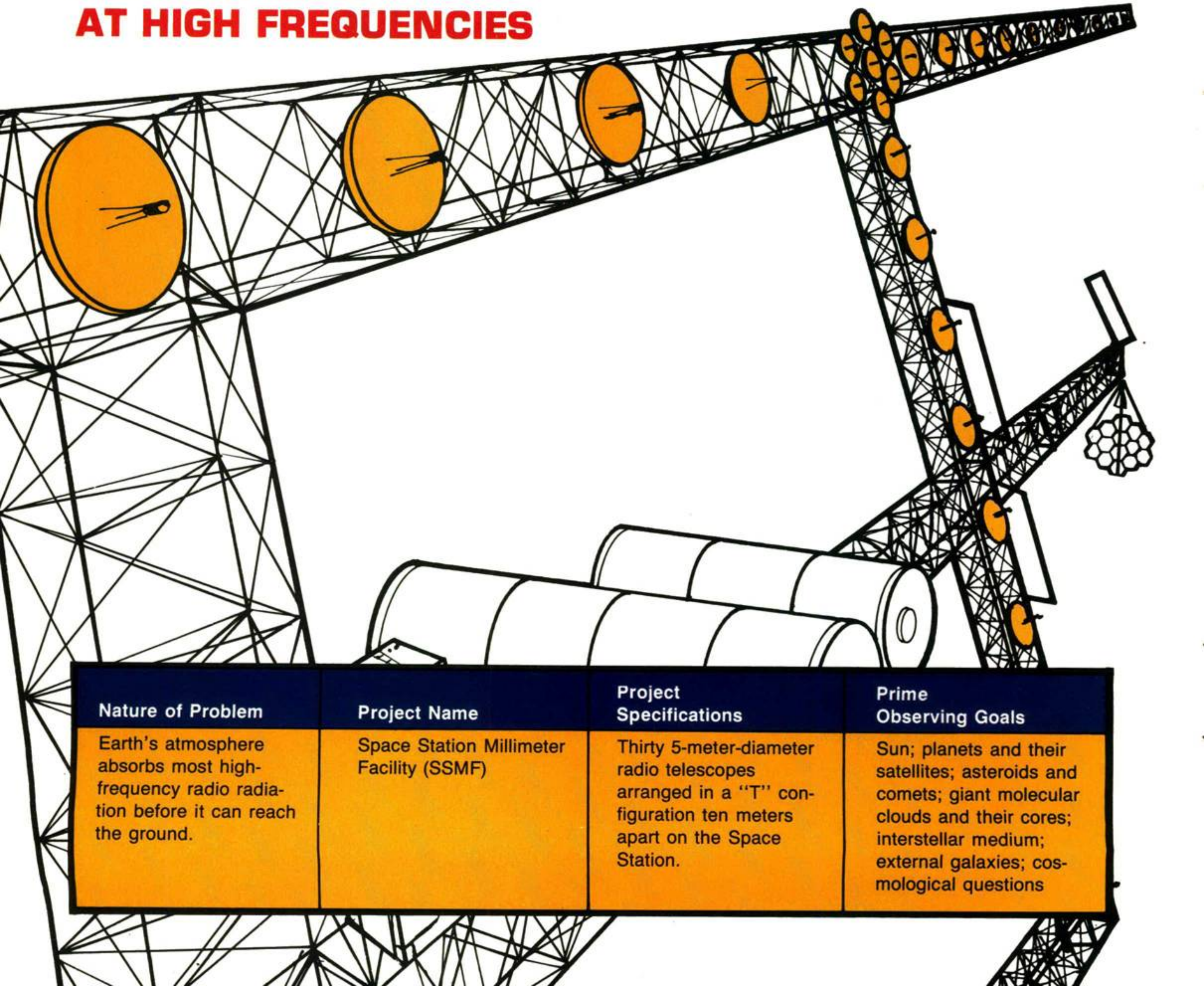
frequency instrument will reveal structures in the magnetic fields of the planets and show how these fields interact with the solar wind, effects that are visible only at low frequencies. Unlike a planetary flyby, where the spacecraft can only observe a planet for a few hours, a low-frequency instrument can study the long-term behavior of planetary magnetic fields.

Even the well-known supernova remnants, pulsars, galaxies, quasars, and clusters of galaxies will appear different at very low frequencies, depending on how they formed and evolved. Both directly and through comparisons with other branches of observational astronomy, new low-frequency observations will improve our understanding of the physics of astronomical objects.

A Low-Frequency Space Array

A low-frequency radio telescope must be at least sev-

A CLEAR VIEW AT HIGH FREQUENCIES



Nature of Problem	Project Name	Project Specifications	Prime Observing Goals
Earth's atmosphere absorbs most high-frequency radio radiation before it can reach the ground.	Space Station Millimeter Facility (SSMF)	Thirty 5-meter-diameter radio telescopes arranged in a "T" configuration ten meters apart on the Space Station.	Sun; planets and their satellites; asteroids and comets; giant molecular clouds and their cores; interstellar medium; external galaxies; cosmological questions

eral thousand feet in diameter to achieve even modest resolution. For this reason it would be prohibitively expensive to place a sufficiently large single antenna in space. However, the well-developed techniques of interferometry are particularly suited to the problem.

The Low Frequency Space Array (LFSA) would consist of a number of free-flying antennas in orbit. The antennas would "fly in formation" and work together to map the sky in great detail and with high sensitivity at frequencies of 1 million to 30 million hertz. At least four separate satellites are needed to produce quick pictures of the low-frequency sky and, more importantly, to permit the use of the most sophisticated data processing and correction techniques.

Each of the satellites in the LFSA would have antennas that could observe a large area of sky at a wide range of low radio frequencies. The antennas also would be designed to sweep the whole sky during each revolution around Earth.

Each satellite would follow a slightly different orbit, and because of the differing forces acting on each one, the array would slowly expand. This expansion eventually allows the antennas to approximate a single telescope several hundred miles in diameter. Thus, the array will be able to map the whole sky at high resolution. Each satellite would have small thrusters to correct for the unpredictable effects of the solar wind and small gravitational perturbations. After the array had grown as large as the scientists desire, the microthrusters could recompress the array and use it to map the sky again.

When the Earth Is Too Small

The problem of reflection and absorption of low-frequency radio radiation by the ionosphere is just one reason radio astronomers are looking at space-based telescopes. Another reason is that even when radio astronomers observe at frequencies that pass through the atmosphere, Earth is simply too small to provide extremely high resolution.

A telescope's ability to resolve details in an astronomical object depends on the frequency at which the telescope operates (higher frequencies give better resolution) and the telescope's diameter (the larger the diameter, the better the resolution). Radio telescopes are inherently lower-resolution instruments than optical telescopes because they observe radiation at much lower frequencies. To overcome this problem, radio astronomers build larger antennas and combine smaller antennas into interferometers that approximate a telescope as wide as the maximum separation between the individual antennas.

The first interferometers were only a few thousand feet to a few miles in diameter. Radio astronomers have expanded their interferometers since then to telescopes that are routinely tens, hundreds, or even thousands of miles in size. Very long baseline interferometry enables astronomers to study extremely small celestial objects in exquisite detail but indicates that radio sources have still smaller components. To study these small components for clues to the energy-production mechanisms of the radio sources, astronomers need even larger telescopes.

One of the most enigmatic discoveries made with VLBI techniques so far is radio sources that appear to expand faster than the speed of light. Such superluminal sources appear to violate the universal speed limit described in the special theory of relativity. No completely satisfactory explanation for these sources yet exists, although astronomers hope higher-resolution studies will shed light on the problem.

Earth-sized telescopes are also used to measure accurate distances across our Galaxy; to monitor the precise motion of Earth as it wobbles, speeds up, and slows down; to establish precise celestial star maps for interplanetary navigation; and to watch the titanic motions of the continents as they drift a few inches per year over Earth's surface.

Although the geological measurements must remain fixed to Earth, the astronomical and navigational problems require telescopes larger than those that can fit on the surface of our planet. Quite literally, ground-based interferometers have reached the ends of Earth, and finer, more precise, and more detailed observations must employ antennas in space.

Bernard Burke, a professor of astrophysics at the Massachusetts Institute of Technology, explained that radio astronomers are drawn to space for "the same driving reason that started with Galileo — namely, the need to get better angular resolution."

Lengthening the Baseline

Three proposals to place a component of an interferometric array in space have been made. The Soviet Union's RADIOASTRON, the European QUASAT, and the Japanese VSOP missions all hope to place an antenna in space during the middle 1990s that would be used in conjunction with VLBI arrays on the ground.

RADIOASTRON will have the highest resolution of the three because it will have the largest orbit. Because the orbit is highly elongated, however, the two-dimensional pictures obtained with RADIOASTRON will not be as good as those from the other two satellites.

QUASAT (a contraction of QUAsar SATellite) will consist of a 15-meter-diameter radio antenna circling Earth in an elliptical orbit that works with antennas on the ground. The system will form a VLBI telescope about 15,000 miles in diameter, almost twice the size of Earth.

Radio astronomers have carried out a number of studies on how to construct, launch, and operate QUASAT., and the necessary technology exists. The satellite currently has a Phase A status, and later this year the European Space Agency will choose to fund one of five Phase A missions. Robert Preston, an astrophysicist at the Jet Propulsion Laboratory and the NASA Study Scientist for the Phase A effort, believes QUASAT has better than a 20 percent chance of getting the go ahead.

Although the United States will not be a major builder of the spacecraft, Preston said, "it's clear that for the QUASAT program to be a success, the U.S. tracking network is a must, and the new U.S. Very Long Baseline Array (currently under construction) is also a must." Along with minor contributions to the spacecraft itself and individual scientist participation, the Americans will play a major role in any European QUASAT mission.

Because the QUASAT will move continually along its orbit, it will act like many different antennas at many different positions and therefore give an unusually high-quality picture of radio sources. The quality of the data will be even better if QUASAT is in orbit at the same time as the VSOP (short for VLBI Space Observatory Project) mission. According to Preston, "VSOP has essentially the same goals [as QUASAT], but it will be in a different orbit and so the two missions can be complementary." And the VSOP mission appears almost certain to win Japanese approval.

The VLBI missions will have a major impact in several areas of research, but the top priority will be active galaxies and quasars. "One of the most active and most important areas of astrophysics is what's going on — what powers the activity — in the centers of quasars and galaxies," said Preston. "With VLBI from the ground we can delve into the innermost parsec [approximately 3 light-years] or so, which gets you down to a region of very high activity. The object is to get even closer to what's generating the activity."

A more distant and costly vision of what radio astronomers would like is a huge interferometer telescope with all its antennas in space. The Astro-Array would consist of thirty radio antennas, each 50 meters in diameter, circling Earth in 60,000-mile orbits — about one quarter the distance to the Moon. All thirty antennas would work together to form a single telescope with a maximum baseline of roughly 120,000 miles. Such an instrument would be a probe of the universe without peer or precedent. It would exceed in sensitivity and resolution anything possible today or even planned for the near future.

The Astro-Array — probably some fifteen to thirty years from reality — could attack a whole range of seemingly impossible but nonetheless fundamental problems. One important task for the Astro-Array would be directly measuring the positions and motions of objects out to the Virgo cluster of galaxies. A detailed knowledge of our cosmic neighborhood would provide better answers to the questions of how large and how old the universe is and what its evolution and ultimate fate will be.

In stellar astronomy the Astro-Array would study the surfaces of other stars in the kind of detail so far only possible on our Sun. And when stars explode as supernovae, radio observations by the Astro-Array will be able to map the supernova's changing structure and determine the velocities and accelerations of the ejected material.

Another target for the Astro-Array would be the powerful masers found in intersellar space and near certain types of stars. These natural masers — the radio equivalents to optical lasers — are regions that emit vast amounts of microwave radiation and are billions of times more powerful than anything conceivable here on Earth.

Mystery at the Galactic Center

At the very heart of the Milky Way, 25,000 light-years away from us, lies a tiny region that emits a tremendous amount of energy. Some astronomers believe a million-solar mass black hole resides at the Galaxy's center, where it emits energy by consuming entire stars. The Astro-Array would be able to examine the galactic center in unprecedented detail, which could help astronomers determine the nature of the mysterious energy source.

In the even more distant future, after humans have established lunar colonies, radio astronomers hope to link antennas on the Moon with others in space and on Earth. The Moon-Earth Radio Interferometer (MERI) would have an effective diameter of nearly a quarter of a million miles, the longest baseline in the foreseeable future. Such a telescope could study the structure of the universe in detail out to and beyond the distant Virgo cluster of galaxies, 30 million light-years away. Even small details in the most distant quasars, out close to the edge of the universe, would be within the range of the MERI.

In addition to the questions we can ask now, VLBI telescopes in space promise a number of surprises. Bernard Burke pointed out that "every time we've made a step to increase angular resolution, we have found things we didn't expect."

Radio astronomers constantly seek ways to open their window on the universe wider. At the highest radio frequencies — radio waves with millimeter and submillimeter wavelengths — Earth's atmosphere starts to absorb radiation just as it does at the neighboring infrared frequencies. Only the clearest, coldest nights on top of the highest mountains are good for observing at millimeter wavelengths. The 14,000-foot top of Mauna Kea in Hawaii is such a place, but even there millimeter-wavelength radio astronomers must wait for both good weather and good observing conditions. At submillimeter wavelengths there is no alternative but to go into space.

Very high frequency radio telescopes in space have one distinct advantage over their lower-frequency counterparts. Because the radiation being observed has such a high frequency, the telescopes no longer need to be thousands of miles in diameter to achieve high resolution. An array only a few hundred feet long is large enough to be at the forefront of astronomical research.

Observing from the Space Station

The permanently manned Space Station scheduled for completion in the 1990s will provide a platform large enough for an outstanding millimeter-submillimeter interferometric telescope. A proposal for the Space Station Millimeter Facility (SSMF) calls for thirty antennas, each 5 meters in diameter, to be arranged over the Space Station structure in a three-arm "T" configuration.

The SSMF would open the submillimeter region of the electromagnetic spectrum for the first time. At millimeter wavelengths the SSMF would beat any existing instrument because it combines greater sensitivity and resolution with the advantage of being above Earth's atmosphere. The facility would tackle a number of astronomical problems including the properties of the Sun's surface, the composition of the atmospheres of the planets and their satellites, the structure and composition of the interstellar medium, the nature of star formation and birth, the structure of the galactic center, and the detailed properties of external galaxies. Even the most distant quasars would yield many of their secrets to the SSMF.

The high-frequency telescope could also look down at Earth's surface to study different properties of crops, forests, land, ice, water, sea, and manmade structures. By looking through Earth's atmosphere tangentially, the SSMF could measure the distribution, dynamics, and density of such important molecules as carbon monoxide, water, and ozone. Two other problems the SSMF could explore are the destruction of Earth's ozone shield and the long-term build up of carbon dioxide, which many scientists believe will cause a "greenhouse" heating of the entire planet.

Radio astronomers will eventually exploit the nearly unlimited frequency range and telescope sizes available beyond the confines of Earth. There are already many fundamental questions that can be asked, and the answers provided by the new space-based radio telescopes will help astronomers better understand our universe. But, as has always been the case in astronomy, the most interesting and most spectacular discoveries are likely to come not from what we expect but from what we are unable to imagine and blindly stumble across.

Kurt W. Weiler is head of the Special Projects Section at the Naval Research Laboratory in Washington, D.C. Brian K. Dennison is professor of physics at Virginia Polytechnic Institute in Blacksburg, Virginia. Kenneth J. Johnston is head of the Radio and Infrared Astronomy Branch at the Naval Research Laboratory.

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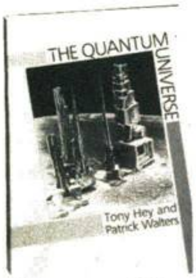
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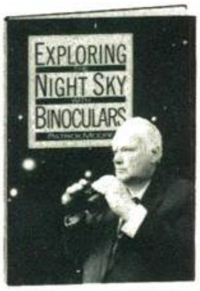
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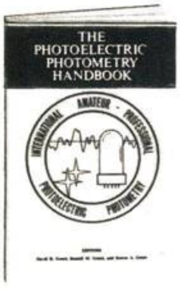
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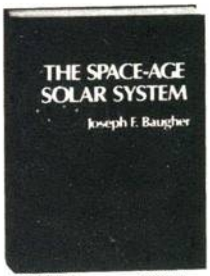
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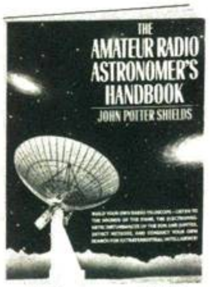
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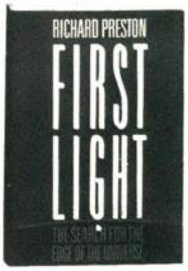
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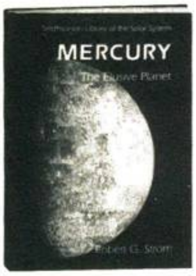
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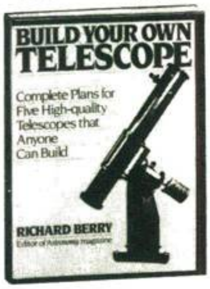
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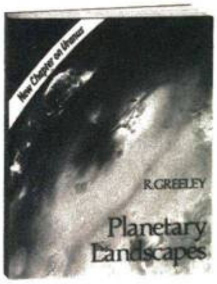
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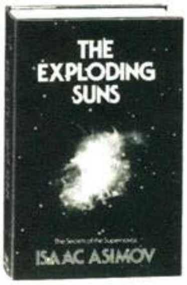
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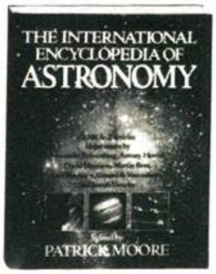
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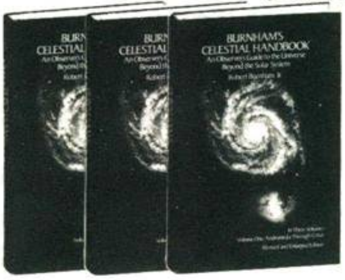
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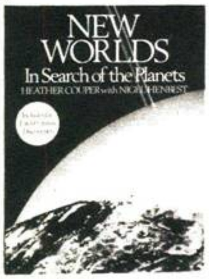
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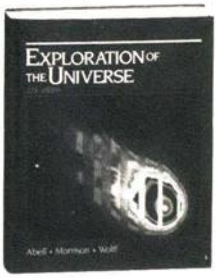
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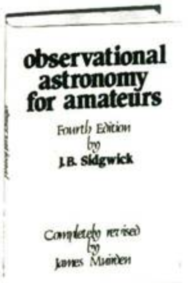
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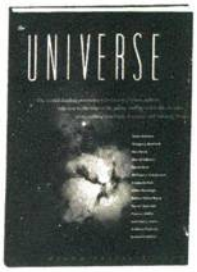

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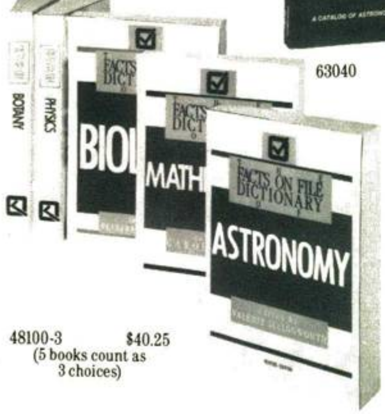
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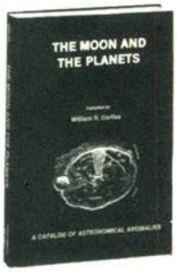
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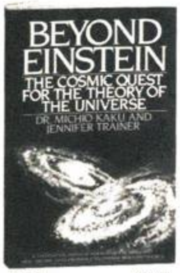
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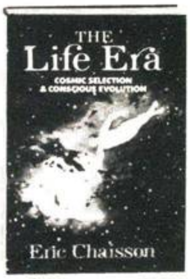
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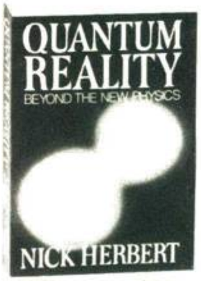
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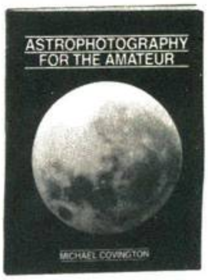
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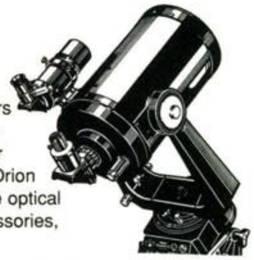

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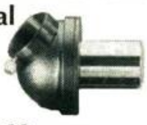

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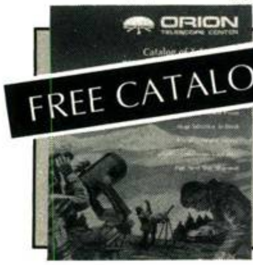

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ASTRONOMY Forum

The Joys of Rural Stargazing

Since I moved to the country seven years ago, I have come to appreciate the advantages of rural life. I can enjoy hiking, cross-country skiing, gardening, blackberry or black walnut picking, bird watching, and weather forecasting — all without leaving my yard. But best of all is the entertainment and education offered by the rural night sky.

Because we live far from city lights, we can observe many sights not discernible to city residents who might have an interest in seeing them. When I lived in a city of 80,000 people, I had no idea when the Moon would be Full and even had to search for the Moon around the buildings. That realization helped me resolve to try the rural lifestyle.

Now, living in the country, I am not only always aware of the Moon's phases, but I was even able to track Comet Halley easily with binoculars through the winter of 1985/86.

Maybe it's because there really is little else to do, but I have found stargazing in the country to be exciting as well as entertaining. When there's nothing else on the agenda, a celestial happening at an odd hour is an opportunity rather than an inconvenience. Thus, a total lunar eclipse at 2 a.m. is a reason to stay up, and all members of the family pass the binoculars around to see it. It doesn't seem that strange to set the alarm for 4 a.m. to catch the peak of the Perseid meteor shower. A planetary occultation is something to mark on the calendar and look forward to.

Not only do these special events have appeal, but even the more mundane celestial happenings become significant. Possibly it's due to the slower pace of rural life, but just watching the changing seasonal skies can be interesting. It's fun to watch Orion rise a bit earlier each night and to track its motion across the winter sky. And it's comforting to see new constellations come into view and know it means a new season is on the way. It makes you respect how time was measured in the centuries before the invention of the calendar watch.

Stargazing in the country also offers a chance to learn and think about the universe. We learn from the world around us and take advantage of the available opportunities, and the sky is an excellent laboratory for such learning. My belief stems from the thinking of writers like Thomas Jefferson and Henry David Thoreau — men who extolled the virtues of living close to nature and the opportunities for self-education and self-realization found in rural living.

The night sky also provides a way to get close to different types of people. Just asking someone if he saw the Moon last night invariably elicits a favorable response. There were many people who did not take the trouble to search for Comet Halley two years ago, but when they found out some of us had done the legwork for them, they were interested enough to want us to point the comet out to them.

Then there are some amateur stargazers with whom it's delightful to share observations and enthusiasm. One of my neighbors has also discovered the joys of stargazing and even owns her own telescope. We get together frequently to track certain objects and compare notes.

But the most important human connection for the rural stargazer is often to his immediate family. Evenings spent on the hillsides are something a family can share and get excited about. Maybe my children will not remember our stargazing as anything more than time pleasantly spent together, although that in itself is reason enough to do it. However, I also think they are learning other lessons from these evening sessions. When his grandmother called attention to a particularly pretty but nontwinkling star one evening, my four-year-old son told her, "That's not a star, that's a Jupiter!" The two of us also compete to see who will be the first to spot the slim crescent Moon following each month's New Moon.

My son is interested enough in watching the night sky that we bought a small telescope ostensibly to aid him in this learning process. He's really too young to use and appreciate it yet, but in the meantime I'm having a lot of

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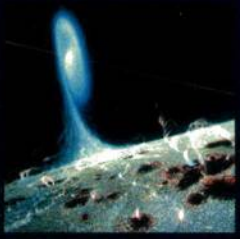

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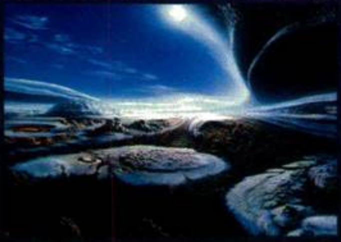

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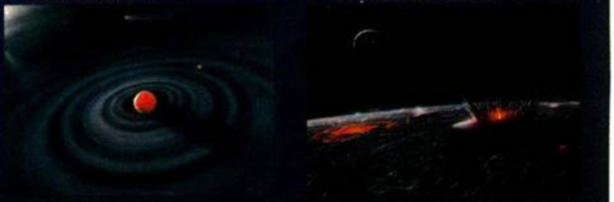

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fun with it.

In the three weeks since I purchased the telescope there have been only four nights clear enough to use it. And on two of those occasions it had been too cold to really learn how to use a new piece of equipment. But on one night conditions were ideal — the evening was cold and clear, the Sun had set over the ridge an hour ago, and the Moon wasn't due to rise above the hills behind the house for another hour.

After much initial fumbling, I was able to see both Mars and Jupiter in the eyepiece, and as a bonus I managed to glimpse Jupiter's moons as well. There was no one else outside and no noise except for my own breathing, but it was an exhilarating moment of triumph nonetheless. The rural night sky once again had given me a reason to savor life in the country.

Gary Williams
Caldwell, Ohio

Fighting Astrofiction with Facts in the Media

Although I was primarily concerned with crime during my eleven years as a newspaper reporter — the who-what-where-when-why of mayhem common to any large city — I occasionally became, by default, the newsroom's resident scientific consultant. As an amateur astronomer, I had more science background than the rest of the staff. In fact, most reporters tend to steer a liberal arts course through their university's curriculum, cautiously avoiding the shoals of mathematics, geology, physics, and astronomy.

Many of us amateurs have seen the results of this lack of expertise in the mass media, but is there anything we can do to correct the problem? I believe it is our responsibility as lovers of astronomy to help the media communicate astronomy to the general public. One simple way to help is introducing yourself to the local press. If a reporter knows a knowledgeable astronomy buff, he will use that person as a resource.

I made one small step for science one evening when a nearly hysterical woman called the newsroom to report that a UFO had followed her home and was even now hovering in the west, ready to disgorge tiny, round-headed aliens. Had NORAD scrambled its fighters yet? Is Conelrad on the air? What should I do?

We all trooped outside to view the invader.

"That's Venus," I said.

"Are you sure?" inquired the editor. Like most of us, he secretly hoped wee, green travelers would one day land and offer celestial gifts, like a cure for cancer or the secret to exploiting the unlimited energy hidden in eggplant.

"Yes," I assured him, "it's been there for a few billion years."

"It's so bright!" the society editor added.

"Albedo," I explained.

"Al who?"

"Reflection. Sunlight reflected off the planet's atmosphere. The atmosphere also produces a greenhouse effect —"

"Right," said the editor. It was enough to know that the wee greenies had not yet arrived and that there was no need to remake the front page to report the story.

I suspect my newsroom was no different from most. News people are not intrinsically dumb or gullible; they just need guidance and solid information. That's our job. Here are five ways you can make your local media's job easier when it comes to scientific matters.

1. Don't be a censor or a critic. No one responds well to the "you idiot!" approach. Reporters are naturally curious, and most are intelligent. The nature of their jobs is to gather and assimilate information, make judgments about what is of public interest, and transmit that information in an easily understood format. The "get that astrology bunk out of the newspaper or I'll cancel my subscription" approach won't work. Instead, offer a valid scientific angle of interest to the public. Chances are the reporter or editor will appreciate the help.

Times
Guard assaulted during scuffle
The Impending Crisis of Space Debris
Inside:

2. Have realistic expectations. Most local news agencies depend on wire services or network "feeds" for stories about the recent supernova explosion or the progress of a space probe. They have limited staffs and limited space or air time available to report the story. And they are more concerned with events that have a local interest.

You can encourage coverage of scientific information and events by localizing the events. Notify the editor or news director when a member of the hometown astronomy club views the supernova from his backyard; make sure the media are aware that an area contractor built the guidance system on a NASA probe. Get meetings and public forums listed in the weekly events calendar. Or call the desk to ask what's coming down the wire about funding for Project Galileo. One or two such calls will often prompt the wire editor to pull a story off the stack and publish it, if only because there seems to be some subscriber interest out there.

3. Offer to serve as an expert source. Reporters and editors depend on others for most of their information. They are generalists who know a little about a lot of things, and they prefer to quote someone when it comes to nuts-and-bolts facts, whether the topic is the municipal budget or the *Voyager* flyby.

News experts needn't possess a doctorate. Usually you just need to know more about a subject than the average layman does and to be available to answer a simple question or two. And that's the key: simplicity. Give a reporter 25 percent of the details and he'll pass half of them along to his readers or viewers. This is far better than no information or, worse yet, outright misinformation.

4. Do something newsworthy. During the Halley encounter, lots of local astronomy clubs and planetariums set up telescopes for public viewing. Some were astounded by the local news coverage as TV cameras swarmed about, catching three-second clips of wide-eyed children and adults peering into eyepieces. Halley was news, and local folks gazing at the comet made local news.

You can re-create that interest, albeit at a lower level of intensity, by proper planning and a few well-placed phone calls. Does your town hold a spring or summer arts festival? Schedule public telescope viewing one evening and tell the editor about it. Is the club sponsor-

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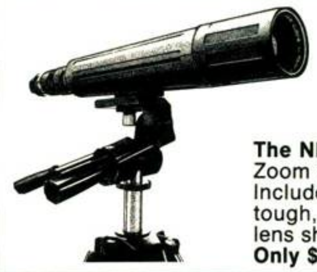

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5. Be persistent. Nothing is as transitory as yesterday's news. Readers and viewers — as well as editors and reporters — move on to something else as the next deadline approaches.

Good media relations are cumulative rather than dramatic. If you succeed in informing and helping an editor three or four times in a year, he'll add you to his list of people to call when an astronomical subject comes up. Even though he may ask the local ancient astronauts/UFO theorist for an occasional interview, the chances are better that he'll also seek a rebuttal or some genuine scientific facts if he knows who to telephone.

Realistically, few newspapers will cancel an astrology column or quit running UFO reports solely because the local astronomy club complains that such information is bogus. Editors know what we must all reluctantly admit: there is a market for this drivel, and a substantial percentage of the population believes extraterrestrial visitors are hiding out there in the swamp.

Our task is to blunt myth with a regular dose of fact. By being aware of what the media reports about science in general and astronomy in particular, we can add a dash of sanity to the mix. It is a task worthy of all of us, and it's one that can be accomplished with minimal effort.

Mike Brake
Oklahoma City, Oklahoma

How I Learned to Coexist with Trees

Trees are opaque. This is not necessarily bad — unless you like astronomy. If that is the case, and you happen to live among the leafy things, trees rank just behind the weather in determining your observing schedule.

Fear of trees kept me from buying a telescope for years. I owned a small and inexpensive 4-inch Newtonian reflector as a kid, an instrument that introduced me to the joys of the sky. However, college, a job, a family, and a house on a wooded lot in suburbia reduced my once keen interest to a faint, fond memory.

Nevertheless, what goes around comes around; in my case what came around was Halley's Comet. Clutching a tiny map torn from the newspaper and a much beloved copy of *Norton's Star Atlas*, I took my 7x50 binoculars into the backyard and peered through barren autumn branches at the sparse, faint starfield below the Great Square of Pegasus. After what in retrospect was an embarrassingly long search, the faint fuzzball swam into view. Delighted, I summoned my twelve-year-old daughter and my dutiful but somewhat skeptical wife to view the apparition — and the rest is history.

Soon I was subscribing to ASTRONOMY, poring over telescope ads, and drooling at pages packed with gleaming hardware. Finally the day came when I could stand it no longer. After making endless lists of features and cost comparisons, I picked up the phone, dialed a toll-free number halfway across the country, and plunked down my plastic. Five days later the boxes arrived, and my battle with the trees began.

I discovered there is always at least one spot on a wooded lot not obscured by trees — the area directly over the house! To look at something overhead, the scope must be placed near the house. To look at something farther south, the scope must be set up close to the trees and pointed back over the house. To look at objects near the horizon — you're out of luck!

I soon learned where the good spots in my yard were, although their number was severely constrained by that other nemesis of backyard astronomers, the neighbors' floodlights. Trees are an advantage here: a well-placed holly tree guards one of my best spots.

Just as I was beginning to think I had the problem licked, a second tree problem arose. Besides making leaves, trees also make pollen. My first inkling of this came one night in April. I had invited an interested friend and his wife over to see my new telescope. We were trying to catch glimpses of the open clusters in Auriga and Gemini through a covering of scattered clouds when I noticed I was having trouble finding objects even when no clouds intervened. I looked at the corrector plate of my new SCT to see if dew had formed and a fine dusting of yellow-green powder met my eyes.

"Gosh," I said, trying to hide my panic. "That looks like pollen."

We packed it in for the night, hoping better times would soon return. But the pollen season lasted almost a month. By the time the yellow blizzard ended, my optics were once again clean, but not before I learned that early spring is off-limits to astronomers who live among the trees.

Summer marked the beginning of my quest for M7. This glittering loose open cluster, one of the crown jewels of the Scorpius-Sagittarius Milky Way, became the litmus test of my ability to coexist with trees. M7 is the southernmost of the Messier objects and a beautiful open cluster well worth the effort of finding. But its −35° declination puts it squarely in my foliage, seemingly out of reach.

This was a challenge that could not go unanswered. Viewing M7 became an obsession. I searched for open fields with a clear view to the south. One night I noticed a small break in the crown of one of the trees in my neighbor's yard. I calculated that if I set up my scope just *so* in my side yard and if my neighbors obligingly turned off their floodlights, my search would be rewarded.

That night I set up at the appointed place and waited for the sky to move through my tiny arboreal window. I busied myself resolving doubles in Scorpius and viewing Saturn. At last I lowered the scope toward the trees. M6 appeared just above the limbs, a "lovely object, with embedded orange star and trailing cluster as well," according to my journal entry.

I moved the scope southeast and there, in a gap in the branches, M7 sparkled and glowed. I watched for a few moments as this stellar beauty swam across the minuscule opening before disappearing. The remaining treasures of the Scorpius-Sagittarius region were merely icing on the cake. I had conquered the trees once and for all!

Michael Masters
Fredericksburg, Virginia

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When you're one of the largest mail order telescope dealers in the country, as we are (with over 250 telescopes in stock and over 250 more scheduled to arrive in the next few months), and a good deal comes along, you can make volume buys that smaller dealers simply can't afford. For instance, we just bought out Meade's *entire inventory* of 6" Deluxe Series reflectors and are closing them out *at almost $100 below original dealer cost!* We carry only name-brand telescopes and accessories -- from Meade, Celestron, Edmund, TeleVue, Questar, Bausch & Lomb, Lumicon, Motofocus, University Optics, Vernonscope, DayStar, and others -- *and we save you money on all of them!* The special purchase bargains below are just a sample!

Below dealer cost!

Meade
THE LEADER'S EDGE

$1500 Meade 6" reflectors for $669!

Take your pick of two outstanding Meade Deluxe Series reflectors and *save better than 55% off the list price!* Choose the 6" f/8 Meade 628C, with the long focal length and excellent contrast superb for planetary and lunar exploration (Mars will soon be the best it's been since 1971), plus the substantial aperture that makes it excellent for deep space viewing. More amateur astronomers have cut their observing teeth on a high quality 6" f/8 reflector like the Meade 628C than any other telescope type. Or you might prefer the compact 6" f/5 645C, with a bright, wide field that's perfect for deep space nebular and galaxy work, but with enough focal length to make high magnification solar system observing a joy as well, all in a compact optical tube measuring only 30" long. Each comes complete with a pier-type German equatorial mount with latitude scale, latitude adjustment turnbuckle, and leveling screws; a 2" non-vignetting focuser with 1.25" adapter; 1.25" 9mm and 25mm modified achromatic eyepieces; setting circles; AC worm gear motor drive; 8 x 50mm finderscope; lifetime warranty, and more! *$1500 to $1520 list, **your choice for only $669!*** Quantities are limited at these special closeout prices.

The $3000 Celestron Powerstar *II* – $1599!

An open letter to our competitors –

We hear that some of you have been complaining about our low price on this magnificent telescope. Sorry, guys, but our customers deserve big savings more than you deserve a fat profit. For one more month, we're giving our customers Celestron's newest Powerstar ***II*** 8" Schmidt-Cassegrain for only $1599! These are not the older and discontinued Powerstar 8 telescopes some of you dealers are offering. These are Celestron's very latest Powerstar ***II*** models. Our customers get all these features and accessories: Starbright coated optics; 8 x 50mm illuminated polar axis finderscope; 1.25" 26mm Plossl eyepiece (77x); 1.25" 7mm orthoscopic eyepiece (286x); quartz-controlled Byers worm gear drive with power adapters for both AC and penlight battery operation; hand control with built-in map light, controls for optional electric focuser, and dual-axis drive corrector operation; equatorial wedge; adjustable height tripod; deluxe heavy-duty Samsonite-type molded foam-lined carrying case; lifetime warranty; and even more! *$3000 list, **for only $1599!** Our customers save 47%!* (The *new-style snap-on* optional $\$160^{00}$ dec motor that converts the Powerstar ***II*** drive into a dual axis drive corrector for astrophotography is only $\$112^{50}$, while the *new-style snap-on* optional $\$150^{00}$ Powerstar ***II*** electric focuser is only $\$104^{50}$. The optional Dewstar dewcap shown in the illustration is $\$24^{00}$.)

New low price!

Meade
THE LEADER'S EDGE

A $3600 Meade 2080/LX5 for $1595!

Here's a superb 56% special buy savings on a superb 8" telescope – the state-of-the-art Meade 2080/LX5. You get all these features and accessories: the latest multi-coated optics group; 9 x 60mm illuminated polar axis finder; 2" mirror star diagonal with 1.25" adapter; 1.25" Series 4000 Super Plossl eyepiece; quartz-controlled electronic drive with power adapters for AC, DC, and penlight battery operation; hand control with built-in map light, controls for optional electric focuser, drive corrector, and 8x image scanning; equatorial wedge; adjustable height tripod; foam-lined carrying case with lock; lifetime warranty, and more! *$3600 list, **for only $1595!*** (The optional $\$160^{00}$ #39 dec motor that converts the LX5 drive into a dual axis drive corrector for astrophotography is only $\$99^{50}$.)

A $5200 Meade 2120/LX5 for $1995!

Here's a sensational savings of over $3200 on the premier 10" telescope in the entire world -- the very newest Meade 2120/LX5. That's better than 60% off the list price! You get all the features of the 2080/LX5, above, but with a 10" optical system that gathers 57% more light than even that extraordinary 8" scope. Sensational for astrophotography and serious deep space observing from suburban and dark sky sites. Incredible performance within the solar system as well. *$5200 list, **for a mere $1995!*** (The optional $\$160^{00}$ #39 dec motor that converts the LX5 drive into a dual axis drive corrector for astrophotography is only $\$99^{50}$.)

Last chance on a $1400 Meade 6600 for $499!

If you want to see the wonders of deep space with your own eyes, but you don't want to haul around a big scope to do it, here's a nifty rich field reflector exceptionally compact and convenient to use and transport (it weighs only 44 lbs.) – the 6" f/5 Meade 6600! We bought the last of Meade's cosmetically blemished models – optically and mechanically perfect, but with minor external finish imperfections – and priced them to save you over $900! Complete with equatorial mount; adjustable height wood tripod with accessory tray; 1.25" 25mm (30x) and 9mm (85x) modified achromatic eyepieces; 6 x 30mm finder; slow motion controls; setting circles; metal dust cover; lifetime warranty, and more! *$1400 list, **for only $499!** You save 65%!* Add a $310 #784 motor drive for only $199.50 for hands-off tracking and astrophotography. We have fewer than 20 at this sensational savings, so don't miss out on this chance to save a bundle!

We have a limited quantity of $1800 8" Meade 8800CDs at a mere $699, too!

Celestron filter and eyepiece closeouts!

We bought out Celestron's remaining inventory of LPR (nebular) filters and wide angle 1.25" Erfle eyepieces and sale priced them at the regular dealer cost and below! Enjoy better deep space viewing at a savings.

LPR Filter #1, photo/visual, fits Celestron C8/Meade 2080 rear cells, only 50 left, *$150 list*	$75
LPR Filter #3, for visual use, fits virtually any .965" eyepiece, only 10 left, *$90 list*	$45
LPR Filter #4, for visual use, fits virtually any 1.25" eyepiece, only 80 left, *$90 list*	$45
LPR Filter #5, for visual use, fits virtually any 2" eyepiece, only 10 left, *$160 list*	$80
LPR Filter #7, for astrophotography, fits any T-adapter or off-axis guider, only 30 left, *$170 list*	$85
20mm 1.25" Erfle, 61° field, only 65 left; **24mm Erfle,** 54° field, only 15 left, *$100 list, your choice*	$45

FREIGHT ADDITIONAL ON CREDIT CARD SALES

Prices shown include free insured UPS shipment within the 48 continental United States if you pay by check or money order. Add 3% freight if payment is by credit card ($3 minimum freight charge).

WRITE FOR FREE DISCOUNT PRICE LIST

Send a stamped, self-addressed business-size envelope for our free discount price list, unadvertised specials list, and information about how to pick the right telescope. Or, send $2 (refundable with your first order) and a *large* stamped, self-addressed envelope for our full 56-page, 40,000 word catalog that even our competitors admit is the most informative and complete in the telescope industry.

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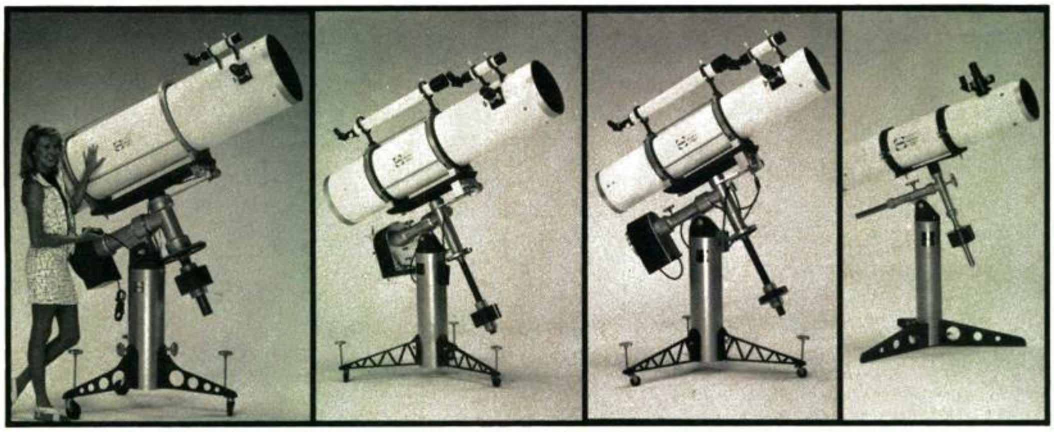

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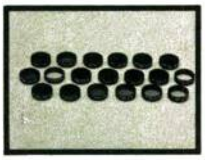

PARKS FILTERS

PARKS SPOTTERS

PARKS BINOCULARS

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PARKS COMPONENTS

FEATURING...

The all new Parks Gold Series 5-element Plossls.

Invest in gold! Invest in the new Parks Gold Series 5-element Plossls. Designed with the latest optical technology and manufacturing from the very finest glasses available. 5-elements design drastically reduces chromatic aberrations and edge distortions. Long eye relief.

FEATURES:

Focal Length	Barrell Diameter	Field of View	Para-Focal	Sug. List	Wholesale to Customer
7.5mm	1¼"	52°	Yes	130.00	$69.00
10mm	1¼"	52°	Yes	130.00	69.00
15mm	1¼"	52°	Yes	130.00	69.00
20mm	1¼"	52°	Yes	140.00	79.00
25mm	1¼"	52°	Yes	140.00	79.00
30mm	1¼"	52°	Yes	180.00	89.00
35mm	1¼"	49°	No	200.00	89.00
3.8mm	1¼"	52°	Yes	240.00	129.00

NEW

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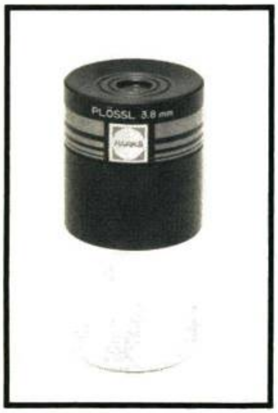

QUALITY — HIGH POWER!

New 3.8mm 1¼" wide field gold series Plossl ocular features:

- 7-element optical configuration
- 52 degree field of view
- multi-coatings
- parfocal
- 1¼" barrel diameter
- excellent eye relief

Introductory Offer

$99

An excellent quality ultra high power ocular for those of you who enjoy POWER. The new 3.8mm, 7-element Plossl can fill the high power gap in your ocular collection. This unique ocular utilizes 7 elements with very low astigmatism and spherical aberration. Renders color corrected images. Multi-coatings increase image contrast. Matte black anodized finish reduces external reflections on the ocular housing. Surface of occular housing designed to "cup" your eye and prevent the interference of ambient light (same as all of the gold series). The ocular element housing of the gold plossl series is designed and manufactured thinner and narrower than standard eyepieces to eliminate unnecessary size and weight and allows convenient eye positioning.

Authorized
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SUPER SALE!

Shown:
2120/LX3 MCOG

Includes Hand Control Unit!

Meade's famous 8 & 10"
LX3 Schmidt-Cassegrains

STANDARD FEATURES & FACTORY-SPECIFIED EQUIPMENT:

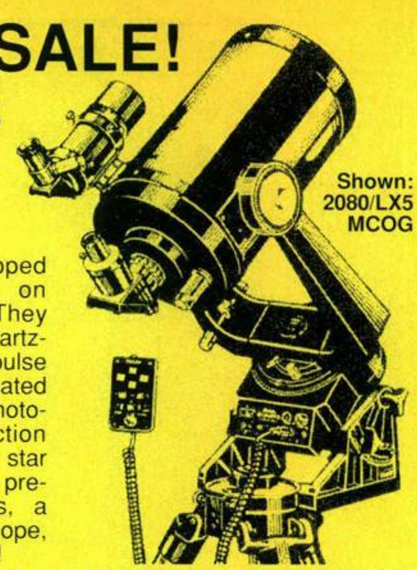
Complete f/10 telescope tube assembly (8" or 10" aperture. 2,000mm or 2,500mm focal length), with certified diffraction-limited optical system: MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity (multi-layer over-coated) mirrors; ultra-smooth anti-backlash focus mechanism; large 8x50mm illuminated-reticle polar-alignment viewfinder; 1.25" visual back (eyepiece holder); 1.25" prism-type star diagonal, anti-reflection coated; Series 4000 Super Plossl eyepiece, 1.25"; rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; quartz micro-electronic sidereal-rate drive system and ultra-precision "LX" worm-drive gearing built into telescope drive base; Power Control Panel (also built into drive base) with controls, indicators and connectors for various accessory and auxiliary electronic equipment; Electronic Command Center hand-control unit **(10" 2120/LX3 only)**; 115V/60Hz AC power adapter with 25 ft. cord; 25 ft. DC power cord w/cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar-alignment adjustments), latitude scale, bubble level and magnetic compass (and no-tool knob set on 8" scope only) ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; instruction manual; limited lifetime warranty.

SUPER SALE PRICED!

2080/LX3 MCOG	(List: $3,320)	**$1,297.95**
2120/LX3 MCOG	(List: $5,000)	**$1,777.95**

FREE FREIGHT! (UPS Ground) for the LX3's shown above

SUPER SALE! Meade's BEST! LX5's


Shown:
2080/LX5
MCOG

The most fully-equipped Schmidt-Cassegrains on the market today! They come complete with quartz-lock microelectronic pulse motor drive, sophisticated hand control unit with photographic drive correction functions built-in, 2.00" star diagonal for advanced, premium-grade eyepieces, a giant 9x60mm finderscope, and much, much more!

STANDARD FEATURES & FACTORY-SPECIFIED EQUIP

Complete f/10 telescope tube assembly (8" or 10" aperture, 2,000mm or 2,500mm focal length), with certified diffraction-limited optical system: MCOG ("Multi-Coated Optics Group"), consisting of multi-layer anti-reflection coatings on corrector plate and enhanced reflectivity mirrors; ultra-smooth anti-backlash focus mechanism; giant 9x60mm illuminated-reticle polar-alignment viewfinder with quick-disconnect mounting bracket; 2.00" mirror-type star diagonal, with 1/10 wave multi-coated mirror and adapter for 1.25" eyepieces; Series 4000 26mm Super Plossl eyepiece, 1.25" (77x or 96x); rugged dual-fork astronomical mount with graduated setting circles; manual positioning controls and clutches on both axes of motion; digital quartz micro-electronic sidereal-rate pulse-motor drive system and ultra-precision "LX" worm-drive gearing built into telescope drive base; Power Control Panel (also built into drive base) with controls, indicators and connectors for various accessory and auxiliary electronic equipment; Electronic Command Center hand-control unit; 115V/60Hz AC power adapter with 25 ft. cord; DC battery pack *(batteries not included)* with 4 ft. cord; 25 ft. DC power cord with automobile cigarette-lighter plug; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth (polar alignment adjustments), latitude scale, bubble level, magnetic compass (and no-tool knob set on 8" scope only); ultra-rigid adjustable-height Field Tripod; dust covers for optical apertures; foam-lined carrying case for scope-tube/fork-mount/drive-base assembly; audio cassette instructions on set-up and applications; instruction manual; limited lifetime warranty.

SUPER SALE PRICED!

2080/LX5 MCOG	(List: $3,600)	**$1,587.95**
2120/LX5 MCOG	(List: $5,200)	**$1,957.95**

FREE FREIGHT! (UPS Ground) for the LX5's shown above

SPRING SPECIAL

Meade's pier-mounted 8" Schmidt-Cassegrain is their very best value in a general-purpose f/10 instrument, thru May 31, 1988 only!

INCLUDES LX3 MOTOR DRIVE

Complete f/10 telescope tube assembly (8" aperture, 2,000mm focal length); ultra-smooth focus mechanism; 6x30mm viewfinder; 1.25" visual back (eyepiece holder); 1.25" prism-type star diagonal, anti-reflection coated; 1.25" MA 25mm (80x) eyepiece; rugged dual-fork astronomical mount with graduated setting circles; LX3 quartz micro electronic sidereal-rate worm-gear drive system; LX3 Power Control Panel with controls, indicators and connectors for various accessory electronic equipment; 115V/60Hz AC power adapter with 25 ft. cord; 25 ft. DC power cord w/cigarette-lighter plug; Deluxe pier-type mount with latitude scale; dust covers for optical apertures; instruction manual; limited lifetime warranty.

MTS-SC8	(List: $2,200)	**$917.95**
MTS-SC8 MCOG	(List: $2,350)	**$977.95**

Special Astrophotography Guiding Accessory Package:

Includes Meade's Mod. 38M Electric Declination Motor and Mod. 36 Dual-Axis Electronic Hand Control Unit for precise, dual-axis electronic tracking corrections during astrophotography. Simple bolt-on, plug-in installation

SC8-PKG#1	(List: $ 370)	**$147.95**

FREE FREIGHT! (UPS Ground) for the SC8's shown above

SPRING SPECIAL

Meade's 6" f/5 and 8" f/4 Schmidt-Newtonians are the very best wide-field instruments available, providing extremely bright, crisp, clear images for visual or photographic work. Thru May 31, 1988, they are available, ***with motor drives*** (Mod. 788 for the SN6, Mod. LX3 for the SN8) at extraordinarily low, low prices. See Meade's ad in this magazine for details regarding specifications, standard equipment and special accessory packages available only during this Spring Special Sale.

MTS-SN6	(List: $ 1,170)	**$577.95**
MTS-SN6 MCOG	(List: $ 1,290)	**$627.95**
MTS-SN8	(List: $ 2,150)	**$917.95**
MTS-SN8 MCOG	(List: $ 2,300)	**$977.95**

Special Astrophotography Guiding Accessory Package:

SN8-PKG#1	(List: $ 370)	**$147.95**

FREE FREIGHT! (UPS Ground) for the SN's shown above

OUR GUARANTEE: We are solely, exclusively, professionally, a first-line, quality telescope dealership. We guarantee, unconditionally, that when you purchase a telescope or other equipment from us, you will receive all of the equipment and accessories that its manufacturer specifies for it. ***We do not*** "strip" scope kits, ***nor do we*** charge extra for the equipment, accessories or warranties intended by the manufacturers to be included with their equipment. When you buy from us, you will receive everything you pay for - you can count on it. We further guarantee, unconditionally, that all equipment sold by us is brand-new and factory-fresh. ***We do not*** take unscrupulous advantage of distant and helpless mailorder buyers; ***we do not*** buy and ***we do not*** sell ***RETURNED***, reconditioned, rebuilt, demonstrator, floor sample, shopworn, used, loaner, rental, prototype, cosmetic defect, factory-second or otherwise imperfect goods. NO OTHER MAIL-ORDER DEALER, TO OUR KNOWLEDGE, MAKES AND PUBLISHES SUCH A GUARANTEE! DON'T BE FOOLED: BUY ONLY FROM A REPUTABLE DEALER.

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CA & AK, OR FOR INFORMATION, CALL (818) 505-8424. Interbank wire transfers. Discover-Card, MasterCard & Visa accepted - no surcharge. Most items free UPS Ground shipping in the contiguous 48 states. California shipping addresses add sales tax. Send business size SASE for ***Free Discount Price List***; $5 ($8 foreign) check or MO for Catalog Package. RFQ's welcome. Prices and specifications are subject to change without notice or obligation. All sales are final.

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CELESTRON

NEW from CELESTRON

POWERSTAR II

Celestron's newest incarnation of their classic fork-mounted Schmidt-Cassegrain is so advanced that it is *ONLY* offered with built-in quartz microelectronic drive corrector (hand control unit included!) and *STARBRIGHT* optical coatings. AC or DC, N or S hemisphere operation, its ready-to-go!

STD. FEATURES & FACTORY SPECIFIED EQUIPMNT - PSC8 II

Complete f/10 telescope tube assembly (8" aperture, 2000mm focal length), with Celestron's world-famous, hand corrected, diffraction-limited, laser tested optical system; *STARBRIGHT* optical coatings group; wide-field 8x50mm right-angle finderscope with built-in illuminated polar-alignment reticle; 1.25" visual accessory holder; 1.25" star diagonal; 26mm (77x), 1.25" barrel, multi-coated, premium-grade Plossl eyepiece; 7mm (286x), 1.25" barrel, fully coated, premium-grade, high-power Orthoscopic eyepiece; rugged dual-fork astronomical mount with graduated setting circles, manual positioning controls and clutches on both axes of motion; digital quartz microelectronic sidereal-rate pulse-motor drive system and ultra-precision 7.5" diameter "BYERS" worm-drive gearing built into telescope drive base; drive corrector hand control unit, with additional controls, and connectors for optional accessory electronic equipment. AC power adapter and cord/plug; DC battery-pack *(batteries not included)*; Deluxe Equatorial Wedge with micrometric adjusters for latitude and azimuth polar-alignment adjustments, latitude scale, bubble level and no-tool knob set; heavy-duty adjustable-height Field Tripod; dust covers for optical apertures; NEW EXTRA-RUGGED MOLDED CARRYING CASE FOR SCOPE-TUBE/FORK-MOUNT/DRIVE-BASE ASSEMBLY, WITH DIE-CUT FOAM LINING AND ROOM FOR ACCESSORIES; Instruction Manual; limited lifetime warranty.

NOW SALE PRICED!

PwrStr-C8 II .... (List: $3,000) $1,587.95

FREE FREIGHT! (UPS Ground) for the PS-C8 II shown above

Super Polaris C8

The SP-C8 is *still* your best dollar-value in a full-featured, significant-aperture, astronomical telescope. The complete kit includes *exactly the same* diffraction-limited 8" Schmidt-Cassegrain telescope tube assembly used on Celestron's much more expensive PowerStar C8 (above), along with a high-quality German-type Equatorial Mount and adjustable Tripod that are loaded with standard features and capabilities.

STD. FEATURES & FACTORY SPECIFIED EQUIPMENT - SP-C8:

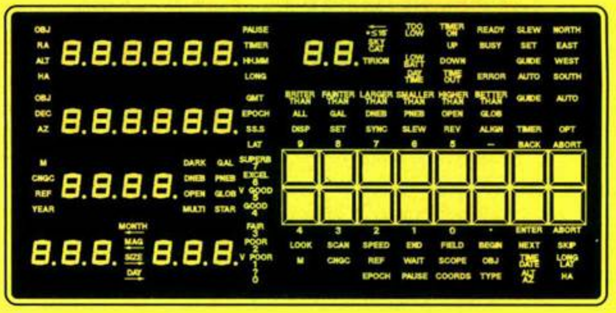
Complete f/10 telescope tube assembly (8" aperture, 2000mm focal length), with Celestron's world-famous, hand corrected, diffraction-limited, laser tested optical system; 6x30mm straight-thru finderscope; 1.25" visual accessory holder; 1.25" star diagonal; 26mm (77x), 1.25" barrel, multi-coated, premium-grade Plossl eyepiece; piggyback camera bracket; hand strap for holding telescope tube assembly during setup/takedown; quick-mount slider bracket for mounting and balancing scope tube; German-type equatorial mount with: (1) full 360 worm-drive slow-motion/manual positioning controls on both axes, (2) setting circles on both axes, (3) vernier brake/clutches on both axes, (4) micrometer latitude adjuster (0-90 !) with latitude scale, (5) micrometer azimuth adjuster, (6) bubble level, (7) built-in illuminated-reticle polar alignment telescope, (8) sliding-type counterweight on quick-disconnect counterweight shaft, and (9) vibration-damping adjustable wooden tripod with accessory tray; foam-lined carrying case for telescope tube assembly; dust covers; instruction manual; limited lifetime warranty.

NOW SALE PRICED!

SP-C8 .... (List: $1,620) .... $ 917.95
SP-C8 StrBrt .... (List: $1,800) $1,037.95

FREE FREIGHT! (UPS Ground) for the SP-C8's shown above

CELESTRON CompuStar



Celestron's *CompuStar* computer-controlled telescopes are the most awesomely powerful instruments available to the amateur astronomer today. With coordinates and data for nearly 8,000 astronomical objects stored in its memory, and high-rate slew speeds for automatic telescope pointing, CompuStar can take you on a tour of the universe that must be experienced to be comprehended. Even a partial listing of CompuStar's features and capabilities is too extensive to attempt here. Please write or call for additional information, pricing and delivery estimates, or send $10.00 cash, U.S., for our CompuStar Introductory Documentation Pkg.

Each CompuStar telescope or retrofit system supplied by CTC includes: (1) an AC power supply; (2) a multi-function joystick controller; and (3), a 180-page "Stored Object Catalog", listing the data for each object stored in CompuStar's memory, and including page or plate cross-references to the most popular star atlases and catalogs, including Uranometria 2000 V1.

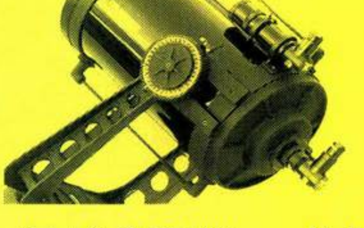
Celestron's CompuStar C14

CC8, StrBrt, W&T .. (List: $ 6,680.00) .... Call
CC11, StrBrt, W&T .. (List: $13,570.00) .... Call
CC14, StrBrt, W&T .. (List: $21,570.00) .... Call

NOTE: WE SPECIALIZE IN CompuStar RETROFIT "COMPUTERIZATION" OF C11's AND C14's. PLEASE CONTACT US REGARDING PRICE, DELIVERY AND OTHER DETAILS INVOLVED IN UPGRADING YOUR C11 OR C14 TELESCOPE.

The Heavyweights

Celestron's C11



Celestron's medium and large-aperture Schmidt-Cassegrains are absolutely unmatched for light grasp and image quality. These scopes give the dedicated amateur the ability to see and photograph the faintest and most distant objects accessible to non-professionals. If you're interested in the maximum in astronomical power, convenience and useability, call . . .

C11, StrBrt, W&T ...... (List:$ 7,570.00) ...... Call
C14, StrBrt, W&T ...... (List:$14,770.00) ...... Call

* * * Notice! * * *

After holding the line on prices for nearly eighteen months, Celestron will revise its prices effective July 1, 1988. Because of generally increased labor and material costs, and especially because of the ongoing decline of the U.S. Dollar relative to foreign currencies, particularly the Japanese Yen, it is expected that most, if not all, of Celestron's prices will increase significantly. This may be your last opportunity to buy at these low prices.

OUR GUARANTEE: We are solely, exclusively, professionally, a first-line, quality telescope dealership. We guarantee, unconditionally, that when you purchase a telescope or other equipment from us, you will receive all of the equipment and accessories that its manufacturer specifies for it. ***We do not*** "strip" scope kits, ***nor do we*** charge extra for the equipment, accessories or warranties intended by the manufacturers to be included with their equipment. When you buy from us, you will receive everything you pay for - you can count on it. We further guarantee, unconditionally, that all equipment sold by us is brand-new and factory-fresh. ***We do not*** take unscrupulous advantage of distant and helpless mailorder buyers; ***we do not*** buy and ***we do not*** sell ***RETURNED***, reconditioned, rebuilt, demonstrator, floor sample, shopworn, used, loaner, rental, prototype, cosmetic defect, factory-second or otherwise imperfect goods. NO OTHER MAIL-ORDER DEALER, TO OUR KNOWLEDGE, MAKES AND PUBLISHES SUCH A GUARANTEE! DON'T BE FOOLED: BUY ONLY FROM A REPUTABLE DEALER.

california telescope company

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ASTRONOMY
In Focus

READERS RESPOND TO THE RIDE REPORT

ASTRONOMY's special report on the Ride Report, "Charting America's Future in Space" (January 1988), drew hundreds of responses from readers. Below we've printed a sampling of those letters.

Public Support Key to U.S. Space Program

Sir / It is no use for the United States to choose a space goal as long as the public does not support space. The United States must first educate its citizens about the potential values of space.

Christopher Gamble
Geneva, Switzerland

Sir / I don't sense any national consensus that manned space exploration is really a national goal. Recall that the *Apollo* program was finally curtailed, and three planned missions were canceled because of a loss of public interest. I don't think the mood has changed much since then.

Park Chamberlain
Tampa, Florida

Sir / The importance of scientific research alone will not generate public support for the funding levels necessary to make any of the four Ride initiatives a reality in the era of national budget deficits. Political, social, and financial commitment to these projects will result only from commercially adaptable discoveries and technological innovations in fields such as health care, communications, and robotics. In short, NASA must create a public relations/education campaign that will show our people the economic benefits of space. The dollar race must be won before the space race can begin.

James J. Kubik
Glenview, Illinois

Competing with the U.S.S.R.

Sir / Hurray for the Soviets! Without them we'd never have gone into space in the first place. Our leadership seems paralyzed until embarrassed into action. Remember *Sputnik*?

W. E. Gatchell, Jr.
Wilbraham, Massachusetts

Sir / Although I'm concerned about the Soviet Union's lead in space exploration, I'd be just as concerned if France or Japan were in the lead. What is more disturbing to me is the United States' lack of vigor in space exploration. NASA will need grassroots support if it is to receive the funding that will be needed.

John Stokes
DeWitt, Michigan

Sir/ I feel it's more important to be ahead of the Soviet Union in the space race than in the military arms race. If the Soviet Union had to "push" to keep up in the space race, there would be less money for military uses.

Betty Sue Tow
Marietta, Oklahoma

Sir / The Ride Report contains a serious flaw. It assumes that America's space program must take place within a narrow political context dominated by the need to establish our undisputed leadership in space exploration. By defining our goals in such petty, chauvinistic terms, we needlessly handicap our efforts and alienate a public that sees the space program as a grand adventure involving all mankind.

Peter Titus
New York, New York

Sir / I am disappointed that your magazine did not question the basic assumption underlying the Ride Report: the objective of space exploration in the next decades must be to establish the United States as the leader in space and to make darn sure everybody knows it.

The question in your Reader Poll about worry over the Soviet lead only served to impress on the respondents the sort of cold war paranoia that demands superiority over the Soviets in every field. When is the United States going to decide that scientific research is worth supporting for its own sake and not only when it is serving political and nationalistic aims?

Jeff White
Etobicoke, Ontario, Canada

Save Money — Cooperate

Sir / All four of the Ride proposals are realistic, imaginative, and should be pursued, but I doubt that our self-indulgent electorate will ever bring itself to pay the bill. The alternative is a genuine international effort, involving not only NASA, Europe, and Japan, but the Soviets and perhaps even India and China as well.

Edward C. Ingraham
Bethesda, Maryland

Majority Rules!

Sir / Dr. Ride seems to understand how our democracy should work. The American people are choosing *not* to fund civilian space projects at this time. In our country this decision must be considered correct.

Jeffrey M. Peterson
Willmar, Minnesota

Sir / Watching "Star Trek" reruns is not supporting mankind's great venture. Register to vote!

Rik Orr
El Paso, Texas

Sir / There should be a box on federal income tax returns that we could check if we wanted to donate to the space program.

Waylon Lambert
Springfield, Illinois

Sir / I agree with the Ride Report in principle, but I cannot believe the same person who criticized NASA so much could duplicate NASA's mistakes. Sally Ride has shown an inability to grasp common sense when it comes to the workings of the U.S. government and NASA. The U.S. government is in the process of attempting to bring its spending under control. Dr. Ride expects that same government to spend trillions of dollars to put a man on Mars. She will probably find out that while people may want a continued presence in space, they probably will not be willing to spend the money required.

Timothy Printy
Orlando, Florida

ASTRONOMY asked all the presidential candidates for their opinions on the future of the space program. The only reply we received, excerpted below, was from Republican candidate Jack Kemp.

Sir / I favor a strong civilian space program, including the space shuttle and a space station. I think space exploration is crucial to improving our quality of life and strengthening our national defense. Money spent in research and development of space programs is well spent and has many applications that will benefit our daily lives and better our understanding of the universe.

Jack Kemp
House of Representatives (R-N.Y.)

The Profit Motive

Sir / The space program of this or any other country will not gain real momentum until it can be made profitable. What this country needs is a strong organization to bring real pressure on Congress to maintain a reasonable level of funding.

Terrence Ripingill
Miami, Florida

Sir / To gain long-term political support, space exploration must provide long-term economic growth. Every move we make must contribute to the goal of making our economy depend on space. The Soviets do not have to take this approach because public support is not necessary for the operation of their space program.

Collins Gittings
Clute, Texas

The Benefits of Exploration

Sir / We are at a crossroad in history. We find ourselves with the ability to leave this tiny planet to explore and colonize other worlds, yet we hesitate.

Sure these ventures come with a hefty price tag, but it's minimal compared to the dollars we spend on defense. In a way we're still living in the dark ages. Our hate, contempt, and distrust for one another keep us there.

But perhaps space can be the new medium through which all men can share a common goal and purpose. Just think about where in the universe man's destiny lies. If on this tiny planet, then what is the virtue in our creativity, the purpose of our imagination and the meaning of curiosity? If we choose to remain Earth-bound, our species will surely stagnate.

Michael Hunt
Hartford City, Indiana

Sir / We should continue with our space program. Being the best is not the most important thing our country can do, but being able to stretch our imaginations is.

NASA has the ability to achieve much more than it has. I am sure that after all the commotion about *Challenger* is over, we will be sending more spacecraft to the Moon and other planets.

We have learned so many things through the space program, but we still have much more to learn about our universe. All the possible ways of doing so are at our fingertips.

Sheri Higley
Jackson High School
Jackson, Michigan

Behind the Scenes

Promote Astronomy with 'Mars Mania'

Amateur astronomers can play an important role in bringing astronomy to the general public. This summer and fall the planet Mars offers you an outstanding chance to do this. On September 28, Mars reaches perihelic opposition — and for a month on either side of that date, it will shine brilliant and orange all night.

Here's how you can do your part. When nonastronomical friends and neighbors ask you what "that new bright star in the sky" is, tell them it's Mars. Invite them over for a look through your telescope. Let them see another world with their own eyes. It's an effective way to get people excited about astronomy.

Astronomy clubs can do even more. Your club could organize a "Mars Mania" star party. With half a dozen telescopes, two dozen volunteer "Martians," and a bit of free publicity on local TV or radio stations, you'll be amazed how many people will come out for a little stargazing.

Once you've got them there, then what? Mars is a difficult object to show the general public. Because a magnification of 150x is required to see much more than a bright orange disk, you'll encounter plenty of people who can't figure out how to look into a telescope, let alone see anything through it!

But don't let that discourage you. Have your most eloquent members prepare short, interesting talks. Prepare a slide show about Mars and the other planets. Even if it rains, you'll have something for people to see. And if it's clear, show them more than Mars — after all, there's an entire sky overhead.

In late summer, for example, you'll have Saturn during the early evening; Mars a bit later; and for the latecomers, Jupiter and its retinue of satellites. Don't forget the Moon either. First-time stargazers love the Moon, especially the crescent or quarter phases. Hold off on the Messier objects until late. Your club and a few enthusiastic visitors can enjoy M13 and the Ring Nebula after the families and kids have gone home.

One especially favorable night for observing occurs in August. On Friday, August 12, the Perseid meteor shower peaks. The combination of warm weather, meteors, Mars, and Saturn could draw quite a crowd.

Finally, let ASTRONOMY know what you're doing. If your group is planning a Mars star party, we'd like to hear from you. Send us the who, what, where, when, and how and we'll help you spread the word with a special feature on "Mars Mania" star parties. The deadline is June 15, so let's hear from you soon.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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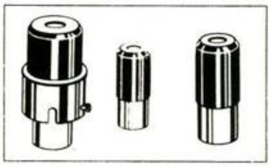

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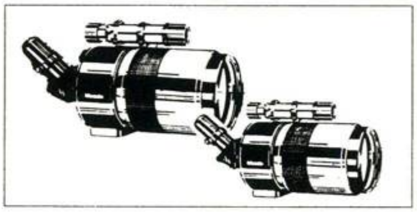

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Our Cosmic Horizons

Part Four: Re-creating the Universe

by Adrian L. Melott

In the final article of this series we put our knowledge of modern cosmology to work for us — in a computer. As close as we can come to containing a working universe in a box, high-speed computers allow astronomers to ask "what if" questions about the universe: What if the superclusters of galaxies evolved from large, flat clouds of gas? What if smaller lumps of matter formed first and then gathered into clusters? Computers can explore these situations and crank out simulations of the physical properties of different expanding universes. These powerful tools are gradually allowing astronomers to separate the true universe from the one obscured within its own complexities.

Computer modeling plays an important role in understanding physical theories because computers allow physicists to more realistically portray the behavior of matter in the universe. With computers, physicists can deal with complex situations and don't have to begin with assumptions that don't reflect reality.

An old joke may shed light on unrealistic assumptions. A farmer was having trouble with his chickens laying enough eggs and couldn't figure out what was wrong. He went to the university and was referred to a physicist. The farmer described his problem and was told to come back the next day. When he did, the physicist said, "I think I can help you with this problem. Let me explain. First, I assume a spherical chicken. . ."

The point is that physicists often assume "idealized" situations to solve problems. In calculating orbits, physicists generally treat planets as perfectly uniform spheres. But putting artificial satellites in orbit led to the realization that planets are "lumpy," so resulting orbits are only approximately elliptical.

Classical physics prefers to deal with idealized situations because the great symmetry and simplicity of these situations permit exact solutions to the equations. Exact solutions to problems in orbital mechanics are possible with uniform spherical planets but not with the lumpy, somewhat squashed shapes of real planets. Exact solutions for cosmological problems — such as the evolution of large-scale structure in the universe — are also possible in universes where independent blobs of matter collapse spherically. But matter does not behave that way in the real universe.

Computers permit a "trial-and-error" approach to the more complicated situations evident in nature. This approach is very different from purely mathematical approaches. Rather than trying to solve the equations, the computer may explore a situation. To calculate an orbit, for example, we would give the computer the laws of gravity, the mass distribution of the lumpy planet, and an "initial state" — the position and velocity of the planet and the satellite. The computer uses the laws of gravity to decide where the satellite will be an instant later, then it uses the data to decide where the planet will be an instant after that, and so on.

In doing this, an orbit is built up from these discrete steps. With this approach we get a particular example of how an orbit can be achieved around an irregular — real — planet.

Doing computer simulations is a bit like theory and a bit like experiment. Simulations are like theory in that we start from some hypothetical situation — the development of spiral arms in galaxies, for example — and let the laws of physics (well known or hypothetical) operate on the elements to decide the future status of the situation. On the other hand, computer simulations are like experiments in that we are trying to see what happens. Sometimes it is possible to do calculations and not understand the result because the key to that result is buried in the complexities of the system. But if we knew or could calculate what would happen, it wouldn't be worth doing a computer simulation in the first place. Looking at the result — whatever it is — can lead to a new understanding.

Explaining What We See

A very active area of research today is studying the growth of structures in the universe on a computer and comparing the results to astronomical data. Because large amounts of space must be simulated, supercomputers are often needed to do the work. A natural thing to do, then, is take a hypothetical early universe consisting of an assumed amount of dark matter and evolve it on a computer to see if we get something that looks like our universe. This way we can assess the relative merits of various ideas about how large-scale structures came to be. Of course, there are many ideas and few facts, but this is how the computer is put to the best use.

Observational evidence over the past decade strongly suggests that galaxies are distributed in vast superclusters that border on equally vast, possibly spherical voids. Astronomers calculate that this rich structure extends to scales of tens to hundreds of millions of light-years. Evidence of structures on even larger scales is more controversial because these scales extend beyond the limits of our instruments. Consequently we know less about those faraway objects.

People have developed a number of ways to explain how this complex structure of superclusters and voids came to be. The earliest theories were based on gravity (see "The Infrared Universe" by Clarence H. Annett, Stellar Frontiers, September and October 1981; and "Cosmology on a Computer" by Adrian Melott, Stellar Frontiers, June and July 1983). Very large scale "wiggles" (called perturbations) in the density of matter in the expanding universe pile up, which causes a bunching of matter. If you imagine a slightly overdense region, you can see that its excess gravity slows its expansion so the region becomes increasingly dense. Eventually the region stops expanding and falls back, forming galaxies. An underdense region, on the other hand, is not retarded by gravity. The more it expands, the less dense it becomes.

We call this kind of behavior an instability. Like a pole balanced on end, an unstable system soon changes. As long as the pole is perfectly upright (or the universe perfectly smooth), nothing happens. But wiggle the pole or put a wiggle in the density field, and the change grows out of control.

An alternative is that the large voids were made by explosions in the early universe. In this theory, independently proposed by Leonid Ozernoy now of the Harvard-Smithsonian Center for Astrophysics, Lennox L. Cowie of the University of Hawaii, and Jeremiah P. Ostriker of Princeton University, the perturbations are the expanding holes blown by the explosions and the surrounding shells of matter being pushed outward.

Another idea is that the matter clumped around "seed loops" left by a network of cosmic strings. Cosmic strings are primordial stringlike distortions created in the enormous heat of the Big Bang. Cosmic strings extend for perhaps hundreds of millions of light-years in loops and are incredibly dense. Both explosions and cosmic strings are different in many ways from randomly placed perturbations.

The Universe in a Computer

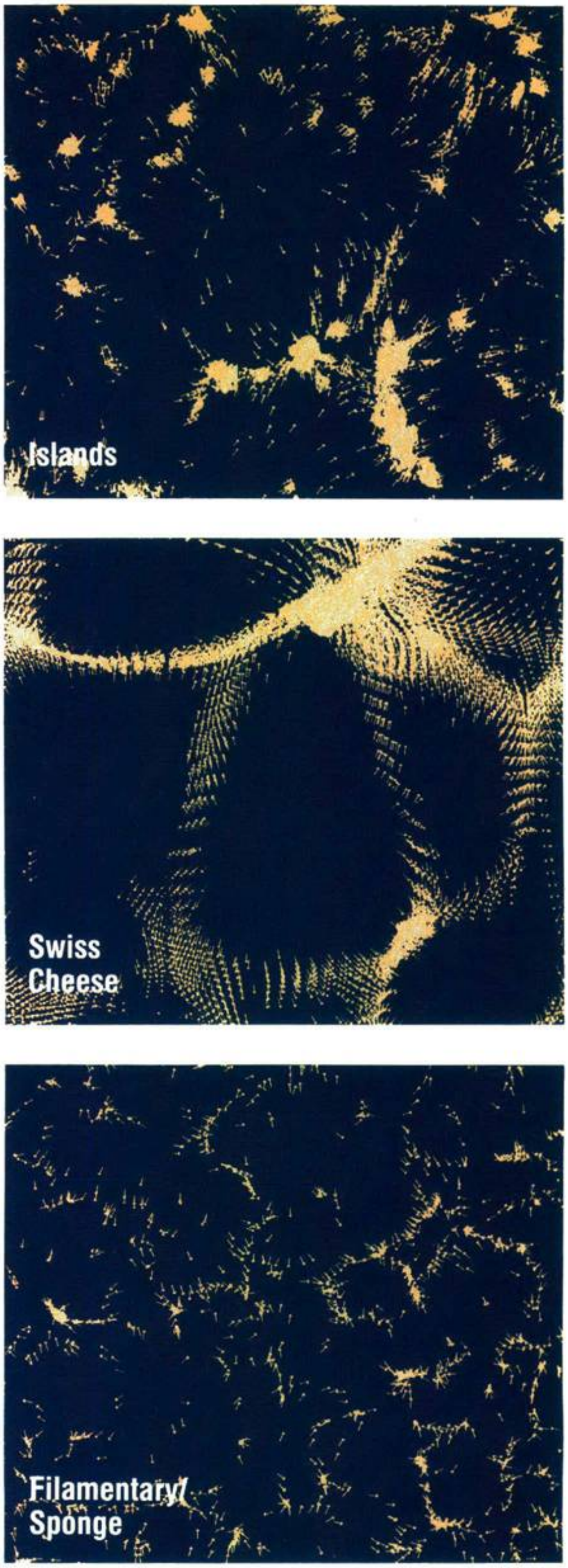
The computer simulations are usually run in a "box" intended to be a sample of a universe. Cosmologists believe the universe tends to become smoother as we look at larger and larger scales, although how fast this happens is somewhat controversial. Our box must be big enough to include the largest interesting scales in the particular problem. We cannot, for example, hope to look for voids comparable to or larger than our box!

A population of "particles" representing matter in the universe is put in the box. Of course, these particles are just numbers representing positions and velocities in the memory of the computer. In cosmological computer models there are usually from a few thousand to a few million particles placed in the box. Usually the particles are distributed very evenly, because we believe the early universe was smooth.

We imagine the box to be expanding with the universe. Thus, if the universe has expanded so the average distance between particles has doubled, we say the box has doubled its size. If the universe stayed smooth, we would see no change in the box. On the other hand, if there were an object of fixed size in the box, it would appear to shrink. Such a system is called a comoving coordinate system, and its use greatly simplifies these computer simulations in cosmology.

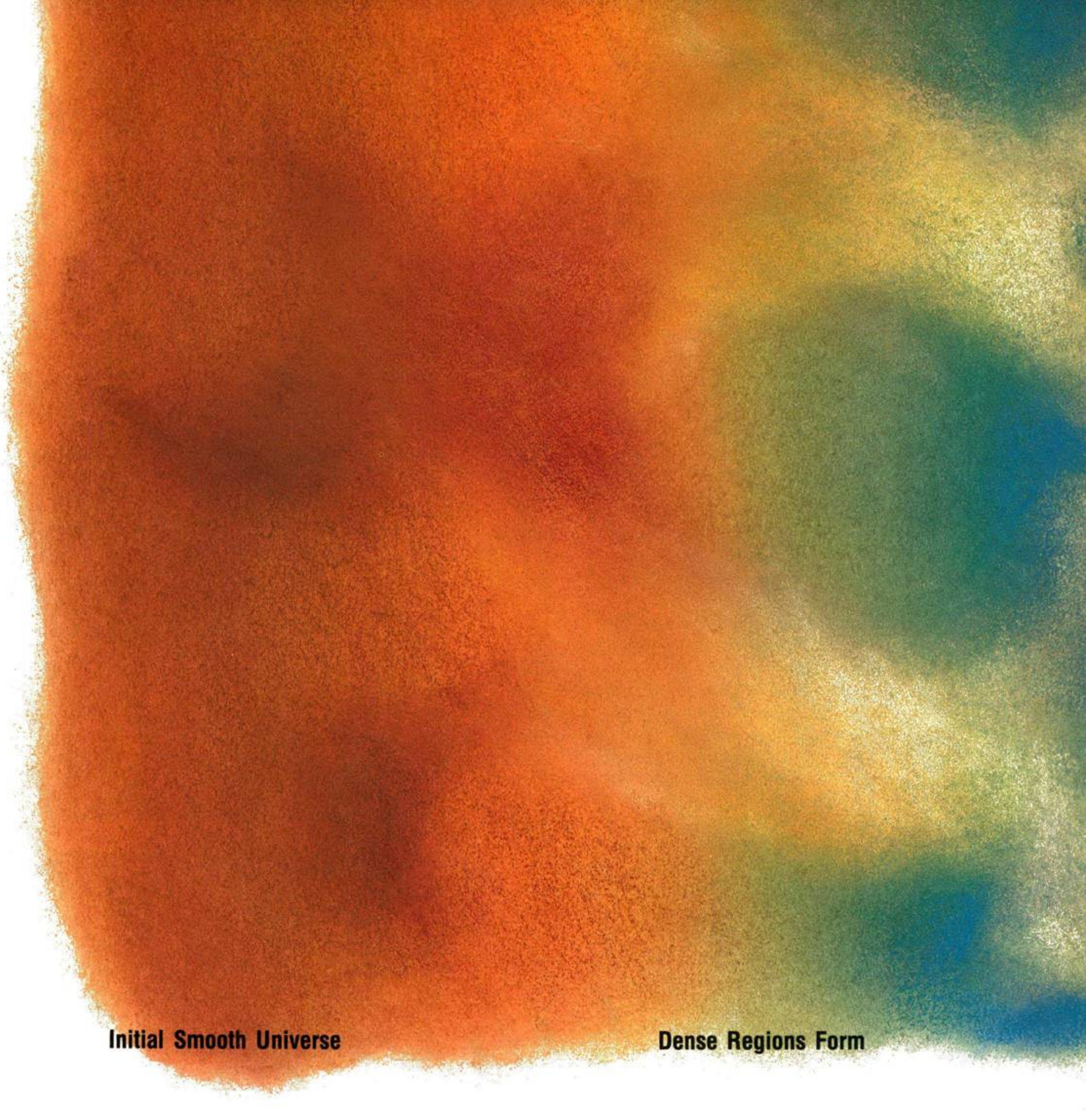
Gravity governs the particles in most modeling experiments because most cosmologists believe gravity is the only really important force over long distances. Some recent computer simulations of the development of large-scale structures based on explosions have also begun to include blast pressure as a force factor. But at cosmological distances, gravity suffices.

How do we deal with the edges of the box? What can we do with particles that leave the box? Our box is supposed to be a finite-sized sample of an infinite (or at least much larger) universe. We can mimic this effect by putting these particles back in the box but on the other side. Each side, then, becomes the continuation of the opposite side. This is similar to saying that on average as much



Early Conditions Determine Present Structure

Cross sections of three universe models demonstrate how different structures develop from different conditions in the early universe. The small arrows represent galaxies and their direction of movement; plots are several hundred million light-years on a side. A universe in which small-scale density fluctuations drive galaxy formation results in an island topology. Large-scale fluctuations result in a Swiss cheese topology. Where both large- and small-scale fluctuations are important, a filamentary topology emerges that, in three dimensions, resembles a sponge. Graphics by Adrian L. Melott.



An Emerging Universe

A universe dominated by hot dark matter starts out nearly smooth. As the universe expands (left to right), matter flows toward lumps of greater density and away from less dense areas, which results in a cellular structure. This matter further collapses into large flattened "pancakes" that eventually fragment into galaxies. Adapted from computer graphics by Adrian L. Melott.

mass leaves the box as enters the box, which is based on the idea that we have a "fair sample" of the universe.

Computer models produce different kinds of results, depending, as would be expected, on the initial conditions — factors that "set the stage" for what happens in the simulation. Roughly speaking, models that produce voids like those seen in the data begin with sizable disturbances in the initial density field that are stronger than those disturbances at smaller scales. I have been studying whether various theories can produce large enough voids, and I am finding that the size of the void depends on which theory is applied.

For example, depending on whether my universe-in-a-box contains fast-moving (hot) or slow-moving (cold) particles, I derive two different results. So-called hot dark matter, of which (possibly) massive neutrinos are the primary constituents, has all of its small-scale density disturbances erased by the rapid thermal motion of the particles in the early hot Big Bang. Hence the hot dark-matter universe has trouble forming structures at small scales until the large scales have collapsed, which some cosmologists see as a problem for this theory.

On the other hand, cold dark matter — which some cosmologists believe may contain massive, slow-moving particles such as gravitinos, photinos, and axions — retains small perturbations and is successful at forming structures

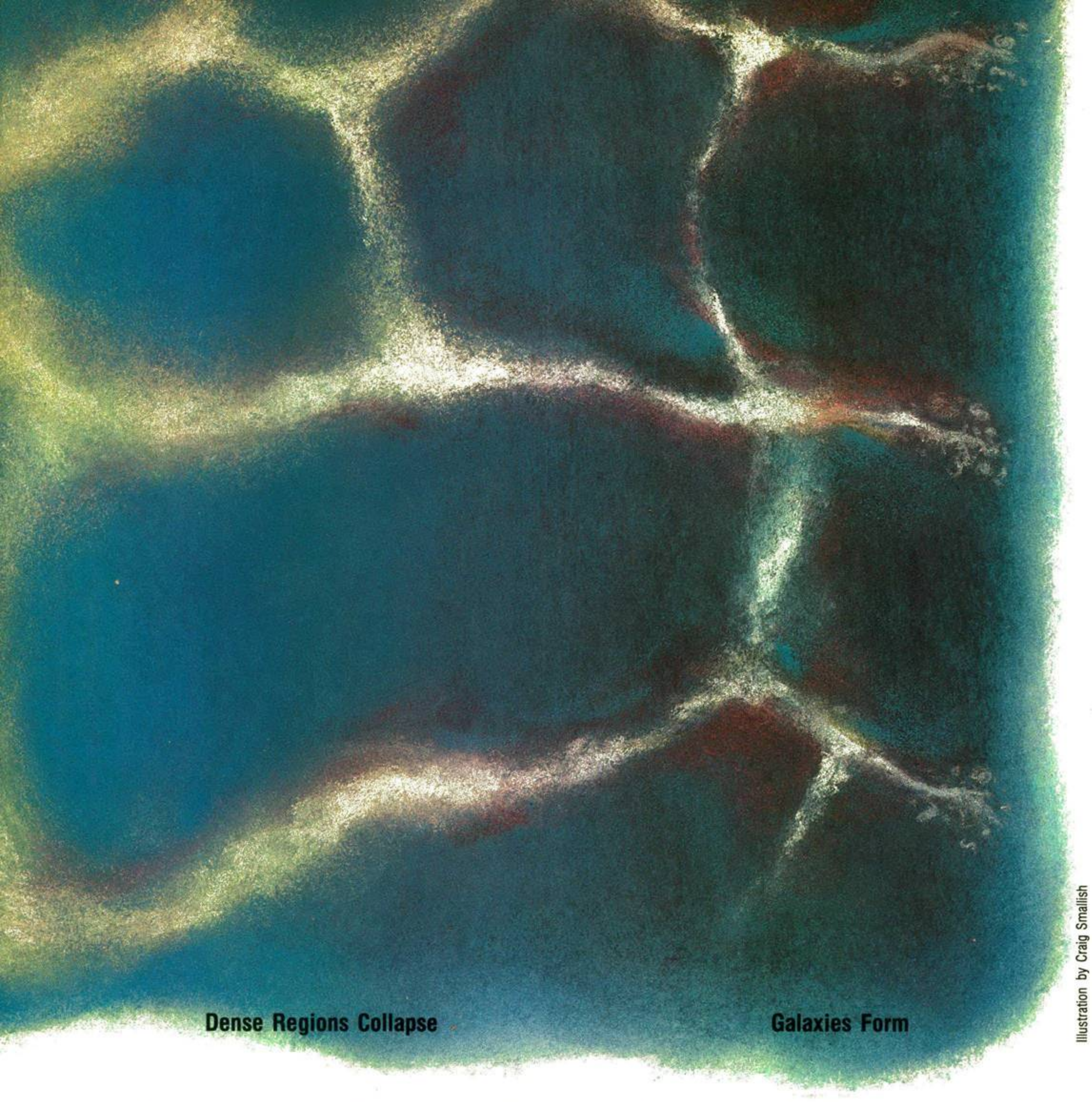


Illustration by Craig Smallish

on small scales. In a universe dominated by cold dark matter, galaxies would form first. But cold dark matter may be unable to account for such large-scale structures as superclusters.

Computer-Predicted Universes

Computer models, because they process so much information, can oftentimes produce unexpected results, as a research group in Moscow led by A. Doroshkevich found out. The group was interested in the "pancake theory" of galaxy formation, which asserts that galaxies should form as a result of the collapse and fragmentation of very large flattened structures. The pancake theory is based on a hot dark-matter dominated model of the universe.

The name "pancake" comes from the expectation that the first things to collapse will be flat. This is true because of the instability discovered by Chia Lin, L. Mestel, and Frank Shu: an irregularly shaped object becomes flatter as it collapses gravitationally. It does so because any part that is closer to the center feels more pull and falls faster. So the shape changes in the direction of the flattening object. Based on the pancake theory, people thought disks of collapsing matter fragmented to make clusters of galaxies.

The computer model the Moscow group used to test this theory was two-dimensional. This means the particles move around in a square on a plane, not up and down and diagonally in the full volume of a box. Such a simulation is like looking at a slice of the universe. In this two-dimensional world the Moscow researchers put their particles down uniformly, except for density perturbations, in the form of "waves" in the particle distribution. In such a hot dark-matter universe, only long wavelengths survive, so a "cutoff" — a minimum wavelength of perturbations — is put into such a simulation.

When later computer simulations were run that showed the processes more clearly as they occurred in the early, middle, and late universe, astronomers were surprised to see a connected "cell" structure rather than "pancakes." No one had expected this from mathematical work. The computer showed what happened. The result can now be used to look back and see why it happened. In retrospect, the result is not hard to understand.

The main reason cells develop instead of pancakes comes from the opposite of the flattening instability we discussed earlier. Consider what happens to an area containing little matter (destined to become a void) in the expanding universe. As the universe's expansion is slowed by gravity, the region around a void isn't slowed as much as matter in more dense regions, because there is less matter within the void to do the slowing, so the void expands in comoving coordinates. Furthermore, the void has an instability similar to the collapsing dense region, but it is an instability that causes the area to become less dense. To stabilize itself, the void tries to become more spherical. This happens because the void is pushing away matter near its boundary. There is less matter at the center of the void and thus less gravitational attraction there, so matter nearer the center feels more "push" and moves away faster. The net effect is for the void to become spherelike. Of course, this has to stop when the void runs into another void.

So the cell structure arises because the overdense regions are trying to become flat and thin and the voids are trying to become round. The only arrangement that can result is the cell structure we see. Later on, gravity causes the cells to break up into isolated clumps of matter.

Although we can explain why this happened from physical laws, the people thinking or doing mathematical calculations did not predict the results from these physical laws but by a "computer experiment." This is a fairly typical example of how new insights can be gained from computer modeling. No one can make an alternative universe and evolve it to see how it turns out. Doing this on a computer, however, introduces a new kind of experiment into a field dominated by observations.

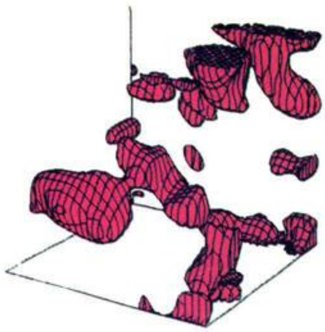
Different Models, Different Universes

When we do a computer simulation of a theory, we have to test it somehow. Scientists do not trust simple judgment "by eye," although that can be a good initial guideline. Objective tests remove the effect of human bias at least to some extent. I am particularly interested in tests of topology — of the structures that develop from initial conditions — because such tests help us determine what went on in the early universe.

Topology is a branch of mathematics that deals with fundamental properties of objects. It is sometimes called "rubber sheet geometry," because it concentrates on properties that are not changed by alterations in shape. One could say that a cube and a sphere are topographically equivalent, because one can be stretched into the other. Neither is equivalent to a doughnut, because punching a hole would be necessary to make the transformation. As we will see, topological models show that the basic idea of gravity acting on density fluctuations is a reasonable way to make structure in the universe, including voids.

We know that in a given theory the size of a void is determined roughly by the biggest perturbation that collapses in a region of space. But what determines the

Cube 1: **Lowest-Density Regions**



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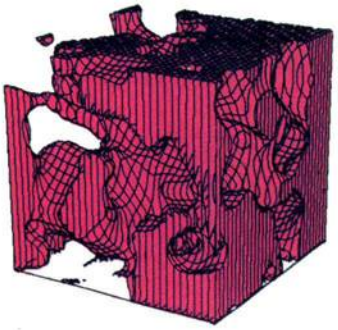
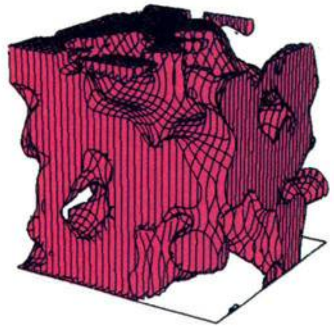
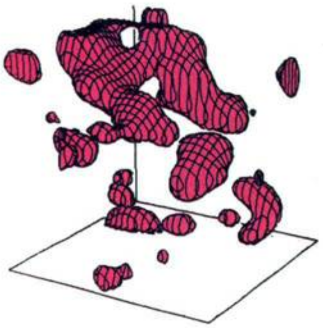


Cube 3: **High-Density Regions**



Cube 4: **Highest-Density Regions**



The Topology of Voids and Galaxy Clusters

The interconnections between low- and high-density regions in a model universe are apparent in these three-dimensional density contour maps. Cube 1 shows the locations of deep "holes" where matter is least dense and exemplifies a Swiss cheese topology. Cube 4 shows the densest regions — the galaxy clusters — and exemplifies an island topology. The middle cubes represent matter at intermediate density ranges: Cube 2 shows the voids but with the contours drawn so half the volume of the cube is enclosed; the contours in Cube 3 depict the distribution of matter in half the volume of the cube. Notice that Cubes 2 and 3 interlock to form a sponge structure in which matter is connected by filaments and voids are connected by tunnels. Graphics by Adrian L. Melott.

topology?

Space can be divided up into matter and voids. From these two phases there are roughly three forms the topology can take: islands, Swiss cheese, and sponge. In the islands picture the matter collects in isolated lumps. The voids, of course, are all connected and extend like the sea around the islands. In the Swiss cheese picture the elements are reversed. The voids are isolated and surrounded by cheese (or matter). The sponge picture is a combination of the two. Matter and voids are interconnected so matter forms a continuous structure and the hollows also form a continuous structure.

Early modelers thought in terms of the islands picture. Such a universe is mostly empty space and matter is segregated to specific locales, so the island analogy seemed appropriate.

Later on, the hot model became popular, and astronomers began to survey regions where there were big voids because the hot model was successful at producing large-scale structures. In this theory, galaxies would not form everywhere there is gas. Basically, they would not form in low-density regions, to better mimic the galaxy distribution. Matter surrounds voids just as cheese surrounds holes in Swiss cheese.

The cold model is in a sense an intermediate level between the islands and Swiss cheese pictures. Both high- and low-density regions seem to be connected; matter and voids make one structure, like a sea sponge.

The sponge topology is in a certain way generic to all these topologies. Computer graphics of a "chunk of the universe," in which structures form according to the cold-universe model, illustrate the relationships. The four cubes on page 46 show the topologies of voids and galaxies; the density of "galaxies" in a region is the basis for drawing the surfaces.

Cube 1 shows the surfaces enclosing deep holes, that is, areas of space with very low densities. Because these low-density areas are isolated, the structures in this cube represent a Swiss cheese topology. Cube 2 still shows the holes, but now the contours are drawn at a level that encloses exactly half the volume; we call this the median density contour. Now we see a topology that is neither the islands nor the Swiss cheese but rather a sponge. Cube 3 shows the opposite phase with the matter above the median density contour. The second and third cubes interlock and fit into each other. Note that both the matter and the voids are connected, like a real sponge. Also, all the holes are connected, so sea water can circulate through the sponge. Cube 4 shows the matter in high-density regions. This looks like an island topology. Notice the symmetry between the high- and low-density topologies. They of course are not identical, but one can say the low-density topology resembles the high-density topology.

What you see depends on the contour that is drawn, which in turn depends on the density of matter. For most purposes we believe it makes sense to talk about how the contour changes with the level. This turns out to be different in different models.

The Seeds of Structure

Most of the models I have talked about look like sponges when the median contour is drawn. The model doesn't depend on the relative importance of large and small perturbations. The perturbations only set the scale for the size of the structure in the sponge.

The reason this turns out to be true relates to the physics at the submicroscopic level. All of the perturbations in the models I've shown are assumed to have somehow arisen from small-scale density fluctuations. Quantum mechanics describes the universe as "noisy" on this small scale. It is like hearing static when you tune in with an extremely sensitive radio receiver. The standard theory today states that this noise was carried to large scales as the universe expanded, thus making superclusters from initial quantum-mechanical perturbations.

Noise is perfectly symmetric. If we are thinking of deviations from some average state, the deviations are just as likely to go up or down. That means our deviations should be symmetric. The sponge topology is symmetric, but neither the islands topology nor the Swiss cheese topology is symmetric, because either one of them changes into the other when we reverse the sign so holes become matter and matter becomes holes. Thus, the very largest structures in the universe may be a reflection of the basic chaos in the universe.

We also have to know how the models based on noise evolve. Do they look symmetric later on? In most cases they do. We have tested computer simulations and are gaining an understanding of what changes may take place and how to detect them. One exception to the symmetry idea is the hot dark-matter model. Because of the "pancake" and "void" instabilities mentioned earlier, this model begins symmetrically, or spongy, but evolves toward the Swiss cheese topology.

Of course, the theory may be wrong. Some astronomers think the large-scale structure may not have been made by gravity but by explosions or chains of explosions blowing holes in the matter distribution. Although detailed calculations have not yet been done, it seems likely this would lead to a Swiss cheese topology. There are other ideas floating around, such as cosmic string loops, which might lead to an islands topology.

Until more complete surveys resolve this question, astronomers are developing further computer tools to measure the topology in a way that yields numbers, a far better approach for research than forming impressions by looking at pictures. At the University of Kansas we think we can detect subtle changes as the structure develops, changes too detailed to discuss here. We have analyzed slices of data to see if three-dimensional structure can be detected in two-dimensional slices. Our results show you can discern this structure in cross section.

What about even bigger scales? Up to a hundred million light-years we can understand voids forming. On larger scales there is no adequate theory to describe the perturbations. Yet we see observational evidence that things are lumpy on those scales too. Still, it is hard to be sure because at the distances and scales involved we are pushing the limits of our instruments.

As galaxy surveys increase and as more powerful telescopes and computers are brought to bear on the universe at large, the search for greater structures will continue. This search could ultimately define our cosmic horizons as never thought possible before, revealing the way the universe truly *is*. The excitement as well as the purpose of the search is in discovering not how science describes the universe but how *nature* describes the universe.

Adrian L. Melott is an assistant professor of physics and astronomy at the University of Kansas, as well as a Unitarian Universalist minister. The computer work described in this article was sponsored by the National Science Foundation.

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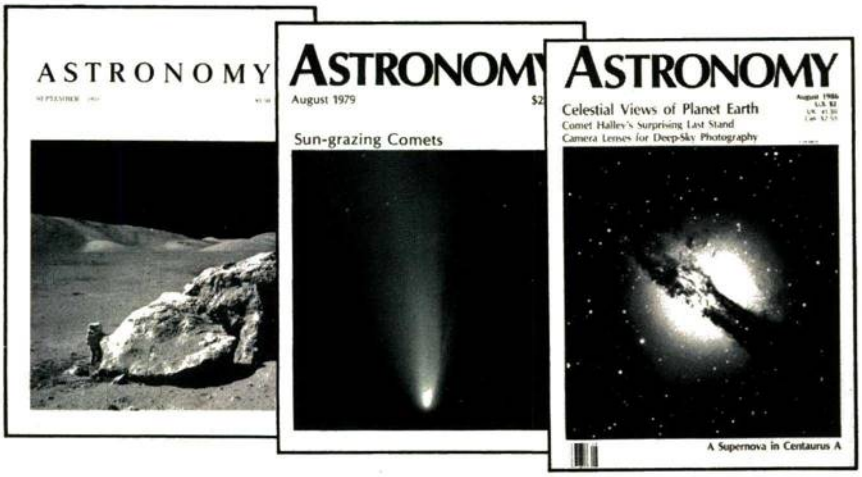
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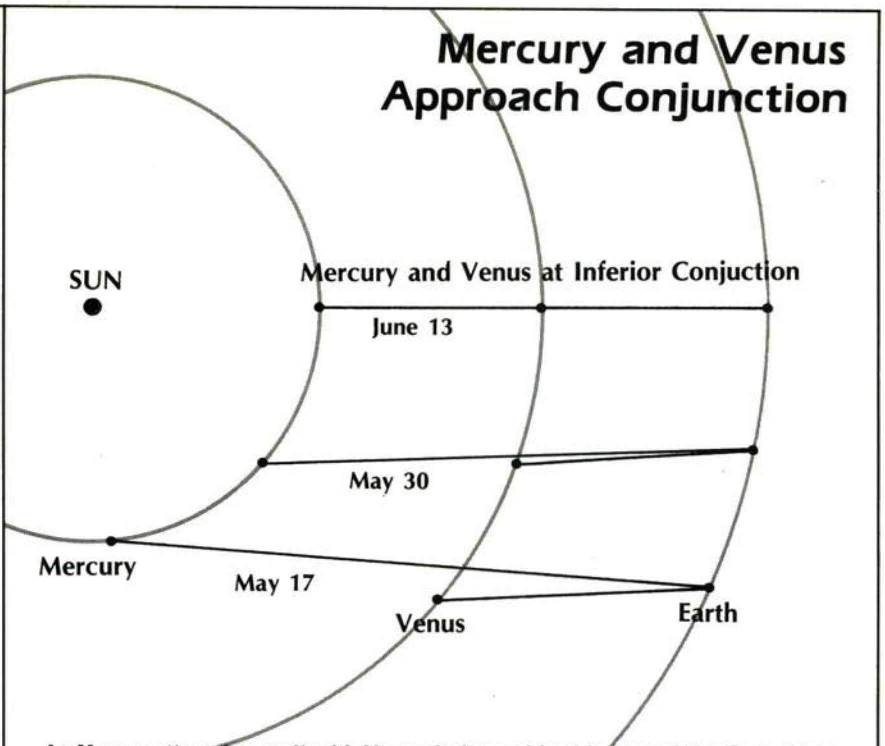
Eye on the Sky

Mercury's Best Show for 1988

by Robert Burnham



Mercury and Venus Approach Conjunction

As Mercury "catches up" with Venus in its rapid orbit around the Sun, these two planets will appear to draw near each other in the evening sky during the latter half of May and sink toward the Sun in early June. Both planets reach inferior conjunction on June 13, and will not be visible from Earth. (See maps on page 52.)

The Wanderers

The first star you see after sunset is actually the planet **Venus**, one of the Sun's family of "wanderers" that moves amidst the backdrop of real stars. Venus shines at magnitude −4.5. It is so bright it can cast subtle shadows and often casual onlookers mistake it for an airplane with its landing lights on or even a UFO.

The other planet in the evening sky, **Mercury**, is much dimmer and harder to see, but this month offers your best chance of the year to spot it. Go someplace where you have an unobstructed view toward the west, such as a park, schoolyard, or ballfield.

Mercury lies among the stars of Taurus, a winter figure now very low and setting soon after the Sun. (Mercury passes a few Moon-diameters south of the famed Pleiades star cluster on May 3.) Early in the month Mercury shines at magnitude −1.3 and will look like a reddish white star low in the dusky sky an hour after sunset.

Starting off May at a low elevation, Mercury climbs straight up, a little higher each evening, until it reaches a peak height of 12° (forty-five minutes after sunset) on May 15. By then the planet will have dimmed to 0.0 magnitude. It passes greatest separation from the Sun on May 19, and continues to drop toward the horizon, fading to magnitude 2.2 by the 31st.

But as Mercury drops in altitude, Venus joins it to make a close pairing of the two planets that lasts a week or more. Here's what is happening.

Venus is moving so it will pass between the Earth and Sun, and Mercury is poised to do likewise. Yet Venus orbits farther from the Sun and therefore moves more slowly. The result is that Mercury rises into view, climbs up to greatest elongation, and then sinks again, while Venus, which has a higher elevation at the beginning of May, drops down to meet Mercury. Then, during the last ten days of May, the two planets slip lower and vanish into the Sun's glare in early June.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

By the time Venus sets, **Saturn** is rising in the southeast, though it isn't easy to see for another hour yet. Saturn lies in the Milky Way in Sagittarius, but at magnitude 0.2 it outshines the stars there. It looks cream- or ivory-white and slowly moves westward against the stellar backdrop during the month. (Toward the end of May Saturn lies due north of the Lagoon and Trifid nebulae. Binoculars should reveal the Lagoon as a distinct hazy patch; the Trifid is smaller but may still be discernible as nonstellar in dark skies.)

While you're in the area, see if you can spot 5.6-magnitude **Uranus** southwest of Saturn and just above the Lagoon Nebula. On June 27, these two planets will pass near each other (1.3°) in the second of three conjunctions this year. (See "The Saturn-Uranus Triple Conjunction" by Richard Talcott, Gazer's Gazette, April 1988.)

To find **Mars**, go out an hour before sunrise and look in the southeast. Mars lies in dim Capricornus and Aquarius, where its 0.0-magnitude brightness dominates the starry background. Its warm-orange hue is distinctive and nothing else in that region of sky challenges Mars' brightness.

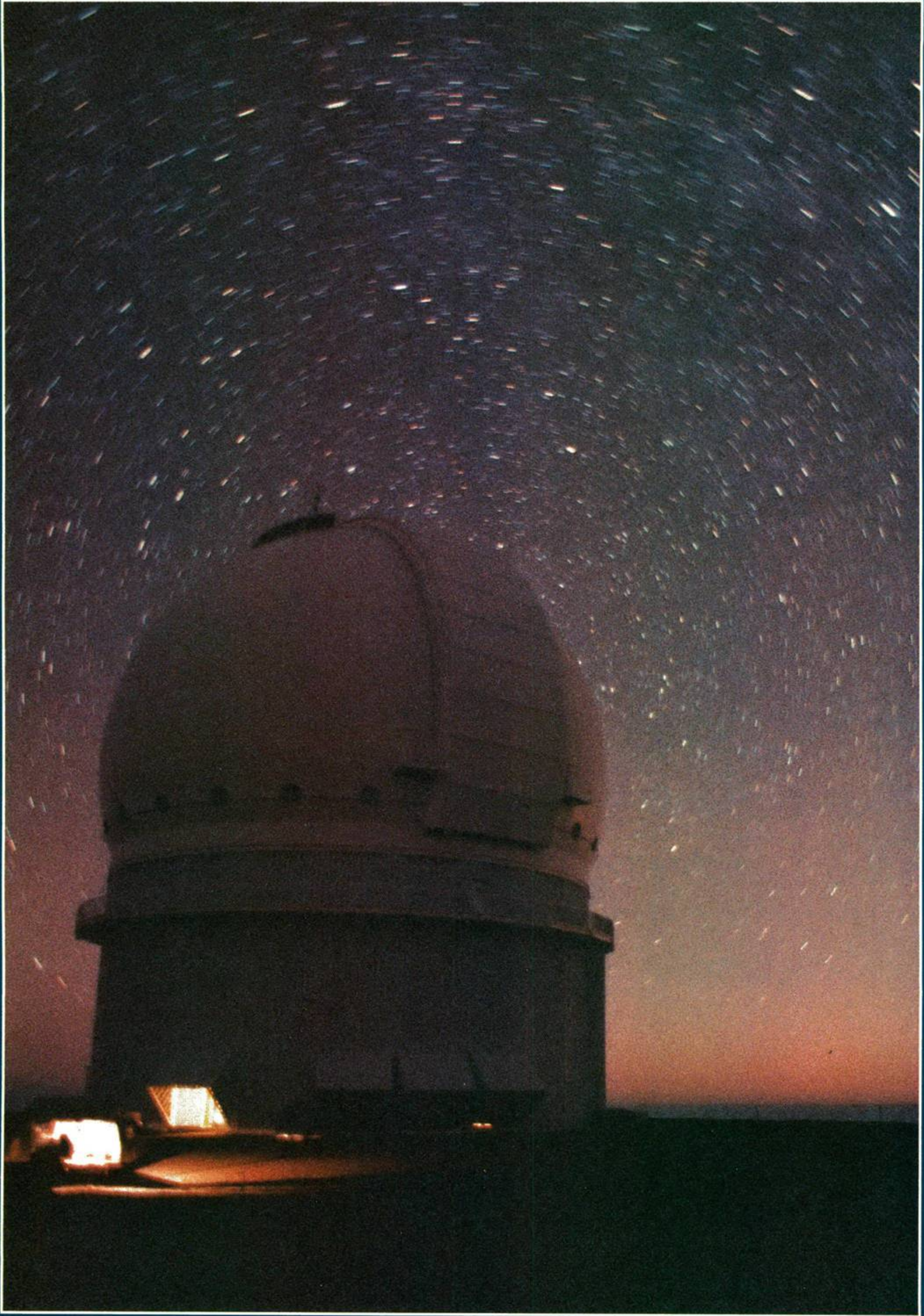
Because **Jupiter** is in conjunction with the Sun on May 2, it will not be visible until late May. Sharp-eyed viewers with a low eastern horizon may catch sight of the −2.0-magnitude planet just before sunrise the last few mornings of May.

The **Eta Aquarid meteor shower**, derived from Halley's Comet, reaches peak activity on May 4, unfortunately during the daytime for observers in the Western Hemisphere. (You must therefore look for meteors in the predawn hours of the 4th or 5th, which are off-peak hours.) Even worse, the Moon (close to Full) rises in the late evening and is visible all night. Normally you would see about fifteen meteors an hour from a dark site, but this year only a handful will escape the "lunar whitewash."

The Starry Sky

The sky of a May evening forms a kind of dark intermission between the theatrical displays of winter past and summer to come. To see the stars without hindrance from moonlight or urban haze, get out of the city into the countryside sometime

Opposite page: The dome housing the 3.6-meter telescope atop Mauna Kea, Hawaii, is bathed in both starlight and twilight. Behind the dome lies the star-trailed circumpolar region; Cassiopeia is at upper right. Photo taken by Scott Rosen with a 24mm lens at f/2.8, Konica 1600 film, and a 5-minute exposure.



May Night Sky

Full Moon
May 1
7:41 p.m. EDT

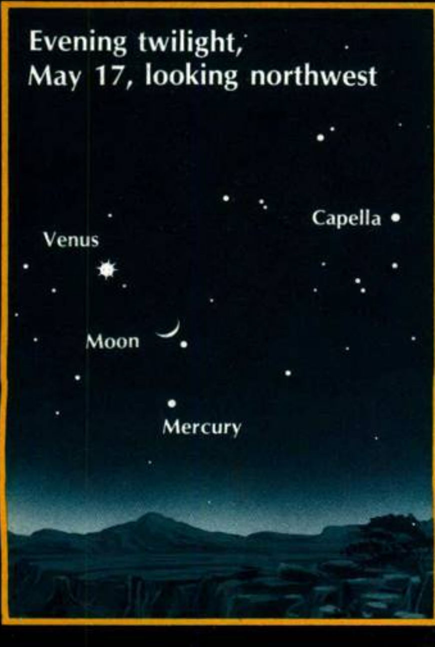
Last Quarter
May 8
9:23 p.m. EDT

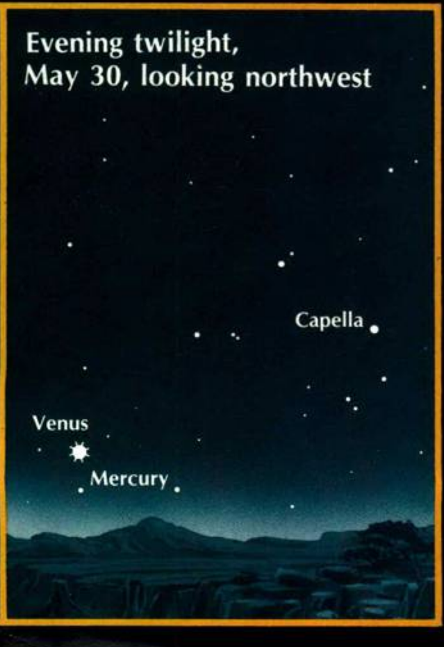
New Moon
May 15
6:11 p.m. EDT

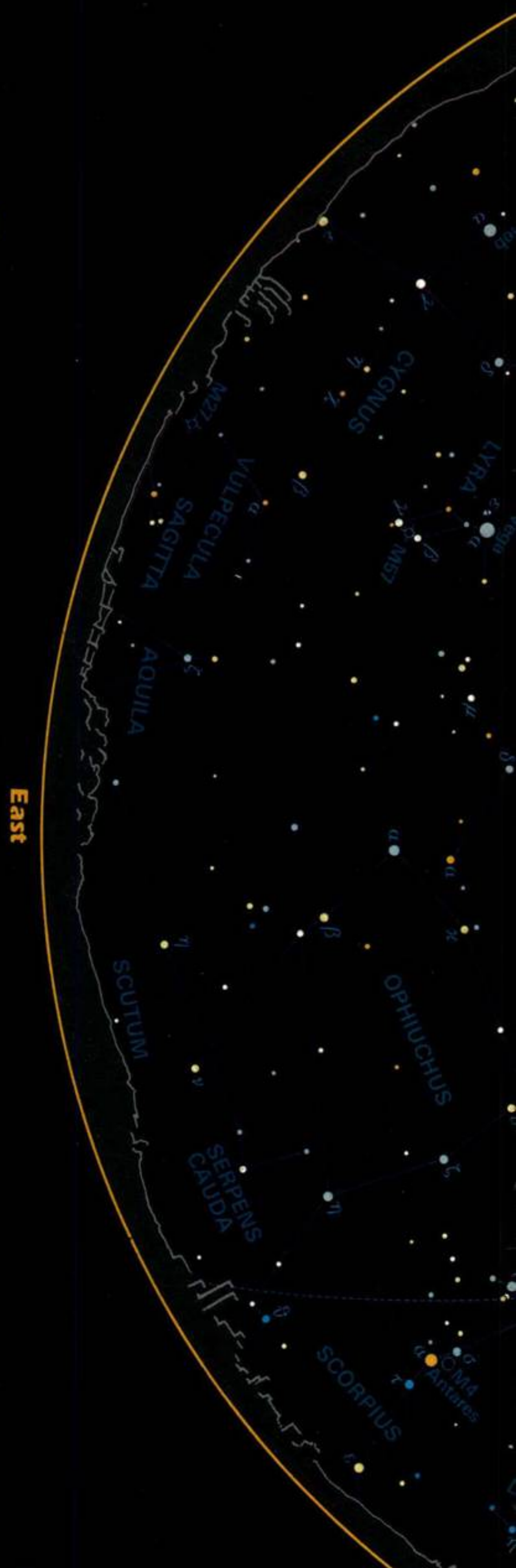
First Quarter
May 23
12:49 p.m. EDT

Full Moon
May 31
6:53 a.m. EDT

1st	The Moon is Full (the first of two times this month) at 7:41 p.m. EDT in Libra. Pluto is at opposition in Virgo.
2nd	Jupiter is in conjunction with the Sun. It will reappear in the morning sky late this month, rising in twilight shortly before the Sun.
3rd	The Moon lies near Antares in Scorpius tonight (and covers the star for viewers in parts of the Southern Hemisphere).
4th	The Eta Aquarid meteor shower is at peak activity today, but the Moon interferes (see text).
6th	Venus is at greatest brilliancy (−4.5 magnitude) in the evening sky.
8th	Last Quarter Moon occurs at 9:23 p.m. EDT in Capricornus. The Moon also passes near Mars, covering it for viewers in parts of the Southern Hemisphere.
10th	The Moon is closest to Earth at 6:30 p.m. EDT: 229,327 miles (369,066 kilometers).
15th	New Moon is at 6:11 p.m. EDT in Taurus.
17th	A slender crescent Moon lies between Mercury and Venus in the evening sky tonight (see diagram below).
18th	This evening Mercury is at greatest eastern elongation from the Sun (and best visibility). Look for it low in the west during the hour after sunset (see text).
23rd	The Moon is farthest from Earth at 9:45 a.m. EDT: 251,094 miles (404,097 kilometers). Three hours later (12:49 p.m. EDT) the Moon is at First Quarter in Leo.
31st	Full Moon occurs a second time this month at 6:53 a.m. EDT in Scorpius.

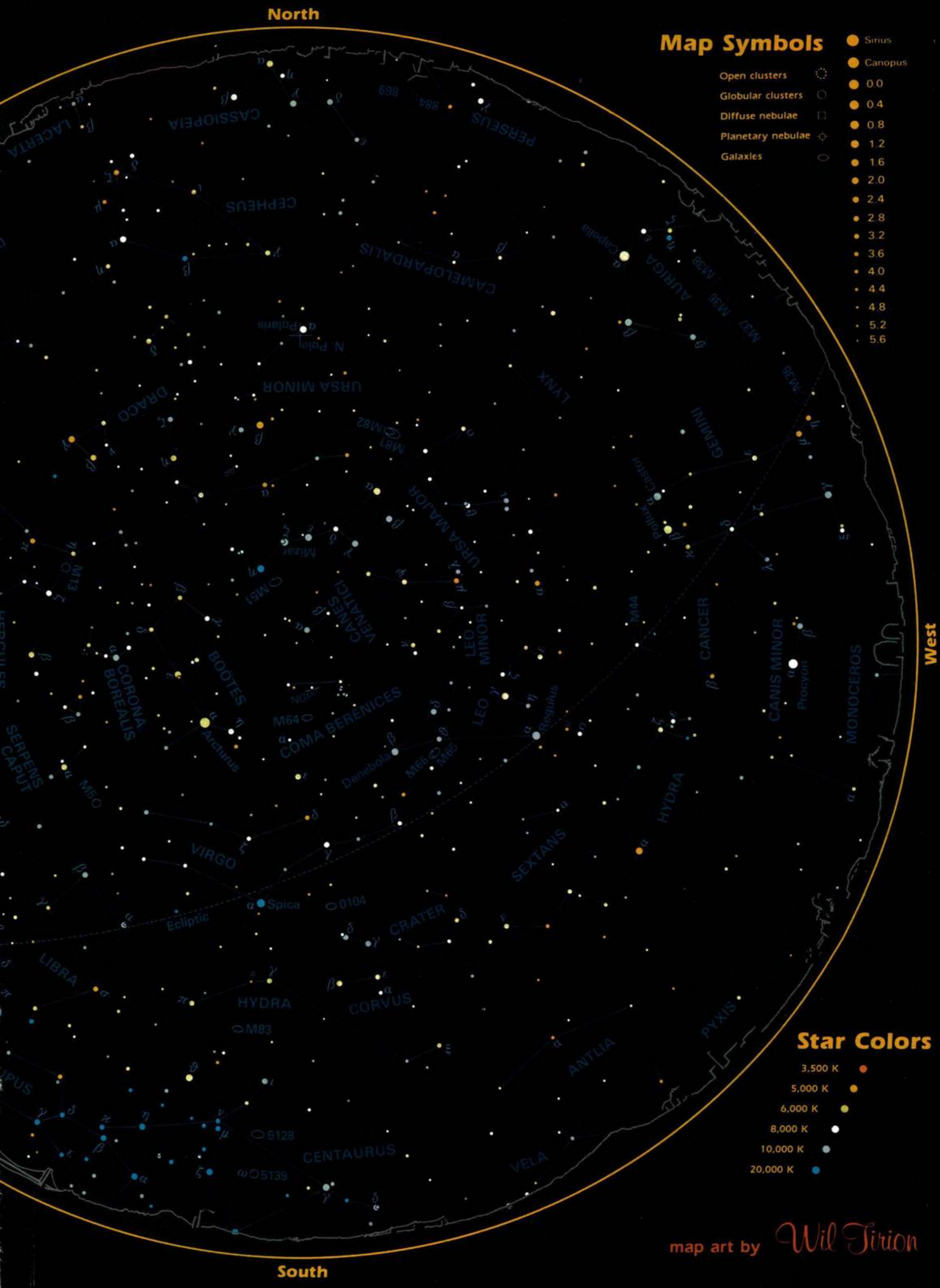

Evening twilight, May 17, looking northwest


Evening twilight, May 30, looking northwest



The Star Dome shows how the sky looks at:

11:30 p.m. on May 1
10:30 p.m. on May 15
9:30 p.m. on May 30


North
South
West
Map Symbols
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
Sirius
Canopus
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
Star Colors
3,500 K
5,000 K
6,000 K
8,000 K
10,000 K
20,000 K
LACERTA
CASSIOPEIA
PERSEUS
869
884
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
M38
M36
M37
M35
α Polaris
N. Pole
URSA MINOR
LYNX
DRACO
M82
M81
GEMINI
Castor
Pollux
URSA MAJOR
Mizar
M13
M51
CANES VENATICI
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0104
CRATER
LIBRA
HYDRA
CORVUS
M83
PYXIS
ANTLIA
LUPUS
5128
CENTAURUS
ω 5139
VELA

map art by Wil Tirion

Opposite page, top: Venus, the waning crescent Moon, and Mercury as they appeared the morning of November 29, 1986. The trio will present a similar composition in the evening sky on May 17. Photo taken by Larry Landolfi with a 50mm lens at f/2.8 and Kodachrome 64 film and guided for 15 seconds.

Opposite page, bottom: Golden-hued northern lights seem to support the Big Dipper as they play over the Mississippi River near St. Cloud, Minnesota. Photo by Bruce Woidyla taken with a 50mm lens at f/1.8, Fuji 50 film, and exposed for 10 seconds.

around the middle of the month, the "dark of the Moon."

Find a seldom-traveled rural road, pull over, and give your eyes about half an hour to dark-adapt. (This is a good time just to stargaze at random with binoculars.) When the sky overhead looks starry enough to silhouette any tree branch, turn to face north and look up.

The familiar Big Dipper (**Ursa Major** the Great Bear) is upside down as if to dash water on Polaris, the north star. The Bear, however, is more than just the Dipper: it has feet extending to the upper left of the Dipper's bowl and a nose pointing down to the left toward Capella, a bright yellowish star low in the northwest. The Little Dipper forms most of **Ursa Minor** the Lesser Bear, but only rural skies will show you the stars between Polaris and Beta (*β*), called Kochab.

Yellow Capella belongs to **Auriga** the Charioteer and is too low to be seen well. To its left stand the tall Twins of **Gemini**, with its two namesake stars, Castor and Pollux, shining at the Twins' heads. On the other side of Gemini is Procyon, luminary of **Canis Minor** the Smaller Dog; it is about as easy to see as Capella.

Back to Polaris. Somewhat to its right you will see the dim, starry trapezoid that forms the head of **Draco** the Dragon. The body of the dragon consists of a line of 3rd- and 4th-magnitude stars that snake between the two Bears. Below Draco is **Cepheus** the mythical King of Ethiopia, a house-shaped figure partly obscured by horizon haze and trees.

If you continue the curve of the Big Dipper's handle, you will "arc to Arcturus," a bright, warm-colored star in **Bootes** the Herdsman, which resembles a skinny kite or an ice cream cone. Bootes is sometimes called the "Bear Driver," because he is endlessly chasing the two celestial bears around the pole.

Facing east, you'll see **Corona Borealis** the Northern Crown as a semicircle of stars just below Bootes. **Hercules** lies to Corona's lower left, a keystone-shaped rectangle with arms and legs extending outward. (M13, just south of Theta [*θ*] in the keystone, is a nice globular cluster for binoculars.) To the lower left of Hercules, blazing white Vega marks diminutive **Lyra** the Lyre.

From Arcturus, let's now "speed on to Spica," an icy-white 1st-magnitude star almost due south. Spica represents an ear of wheat held in the hand of Ceres, the Roman goddess of the harvest. The constellation is now called **Virgo** the Maiden and is depicted in about a dozen 3rd-magnitude stars.

It seems like one arm of Virgo is reaching west to tickle the tail of **Leo** the Lion at the star Denebola. The Lion is resting in a crouch with its forepaws at Regulus and its head and mane in a backwards "?" called the Sickle. Between Regulus and Procyon, the head of **Hydra** the Water Snake is a small oblong of stars. Hydra's body makes a zigzag chain of stars running east under Leo and Virgo. Dim **Crater** the Cup and brighter **Corvus** the Crow sit on the Snake's back.

The zodiac (or ecliptic) is the apparent path the Sun follows over a year. It cuts across this evening's sky from northwest to southeast, passing Gemini, faint **Cancer** the Crab, Leo, and Virgo to reach another dim figure: diamond-shaped **Libra** the Balance. Between Libra and the southeastern horizon the first figure in the summer zodiac is climbing into view. This is **Scorpius** the Scorpion, which will be in full view by midnight tonight — or in the evening hours two months from now.

Skylore

Since Homeric times at least, the stars of the Great She-Bear have been known to be circumpolar: the *Odyssey* (in Richmond Lattimore's translation) mentions that "she alone is never plunged in the wash of the Ocean." The Greeks concocted a tale around this fact that involved (as many legends did) the amours of Zeus.

Kallisto was a nymph who earned the jealousy of Hera by being beautiful enough to attract the attentions of Zeus. To avenge herself, Hera changed Kallisto into a shaggy bear and set her wandering in the forests of Arcadia. One day when Kallisto's son Arkas was out hunting, he saw the bear and drew his bow on it. Luckily, before he could shoot, Zeus intervened to prevent the tragedy.

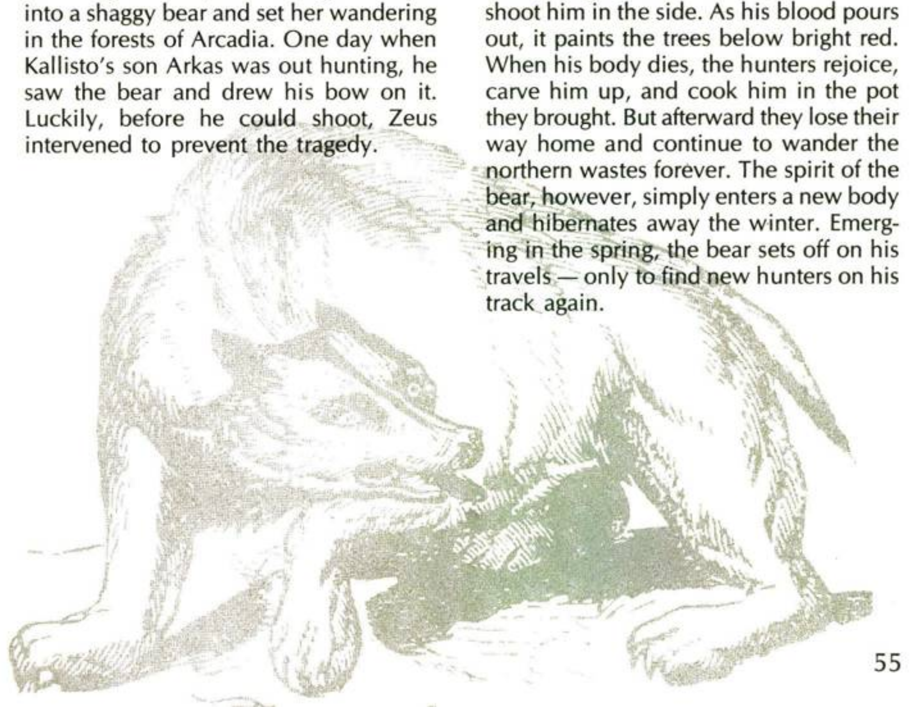
Recognizing that Hera would never leave Kallisto alone — and that other hunters might make the same mistake Arkas did — Zeus grabbed Kallisto by her tail and flung her into the sky where she became Ursa Major. To keep her company, he changed Arkas into a bear as well and he became Ursa Minor. (The story claims that both celestial bears have unearthly long tails because their tails stretched when Zeus made his mighty fling!)

A postscript to the story shows that even then Hera wasn't satisfied. With Zeus able to gaze as often as he liked at her rival, Hera decided further steps were necessary. She made her brother Poseidon, god of the oceans, promise to reject the ursine pair whenever they drew near his watery domain. Never more could either Kallisto or Arkas enter the ocean. And so it remains today — though from the latitudes of southern Greece, Kallisto now sweeps her tail through the water, thanks to the precession of the equinoxes.

We don't know why, but even the Indians of the New World identified these stars as long-tailed bears. The Iroquois said that in olden days *all* bears had big bushy tails. The Earth Bear, however, was vain and often boasted he could gnaw a hole in the ice over a pond, drop his tail in, and bring up many tasty fish. One day, though, it was so cold the hole froze over and held his tail fast. Only by giving up his proud tail could he go free — and that's why all his descendants on Earth are without tails today.

Another Indian star-bear legend explains why the leaves of the northern woods change color in the fall. Three hunters (the handle of the Dipper) are chasing a bear (the bowl) and even carrying the pot to cook him in (Alcor). Round and round they go throughout the year until autumn arrives and the bear is diving to the ground in the evening hours.

Catching up to the bear, the hunters shoot him in the side. As his blood pours out, it paints the trees below bright red. When his body dies, the hunters rejoice, carve him up, and cook him in the pot they brought. But afterward they lose their way home and continue to wander the northern wastes forever. The spirit of the bear, however, simply enters a new body and hibernates away the winter. Emerging in the spring, the bear sets off on his travels — only to find new hunters on his track again.



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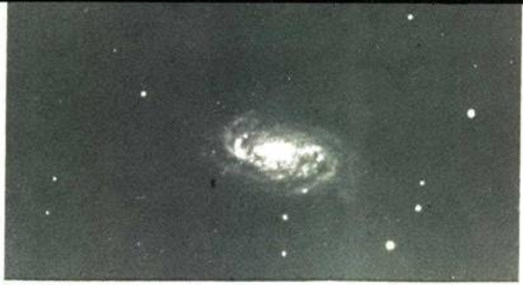

Spiral Galaxy NGC 2903 in Leo. This lovely 9th magnitude galaxy should have been a Messier object. Structural detail and mottling is visible in larger telescopes at 200X. Photo by Ron Potter using LUMICON hypered 2415 film, 2 hours, 14" f/10 (with auto-guider!).

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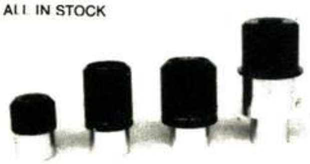

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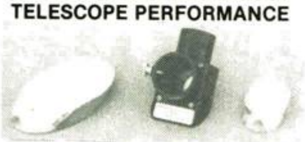

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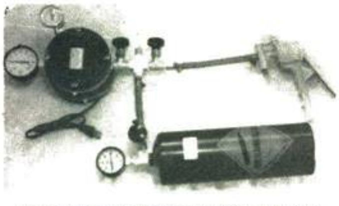

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Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump, Model R-10 **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.

Specify Camera and Telescope type.

U.S. Patent #4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$79.50**
Illuminated reticle eyepiece system ..	**$89.50**

Guider for Hasselblad **$350**, Mamiya 645 **$199**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

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GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER.............. **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)....... **add $99.95**
Adaoter for Hasselblad **$195**, Mamiya 645 **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$89.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.
2. Cable release for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope) .. $70
NEW Deluxe Digital Qtz. Drive Correc. **$298**

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SR1600
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1000
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HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SRV3200, fastest of all, color neg	24	**$13.95**
Konica SR1600, very fast, fine gr.	24	**$12.95**
Konica SR400, fine grain color neg	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

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Livermore, CA 94550 (415) 447-9570

NEW! NON-ROTATING HELICAL FOCUSER

LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON has just designed a deluxe smooth helical focuser with non-rotating 2" i.d. eyepiece holder. It has a vertical travel of 1¼" and a very low profile only 1½" high. It is CNC machined, black anodized, and a perfect match to LUMICON EASY-GUIDERS.

Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 20" OD, SUPER-FINDER base plate.

LUMICON Deluxe Helical Focuser	**$79.50**
3 handles (see photo)	**$12.95**
Helical focuser with 3 handles	**$92.40**
2"/1¼" adapter w/48mm filter threads	**$20.00**
2" LUMICON EASY-GUIDER	**$169.50**

EYEPIECE PROJECTION

These adapters allow high magnification photography of the Moon and Planets using eyepiece projection. They may be used without any eyepiece for prime-focus photography. All adapters use standard camera T-rings.

Tele-Extender for Meade or Celestron SCT.	**$32**
1¼" Basic Camera adapter, 2 part system	**$32**
0.96" Basic Camera adapter, 2 part system	**$32**
1¼" prime Focus adapter, fits 1¼" focuser	**$22**
0.96" prime Focus adapter, fits 0.96" focuser	**$22**
Camera T-ring, specify 35mm camera type	**$12**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F=500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER	**$169**
1¼" right-angle version, w/star diagonal	**$195**
2" right-angle version, non-rotating focuser	**$199**
1¼" Deluxe right-angle Super-Finder*	**$279**
2" Deluxe right-angle Super-Finder*	**$309**
25mm Cross-hair 1¼" eyepiece (12X)	**$29**
*1¼" Star Diag. **$32**, 2" Star Diag., silver,	**$145**
1¼" Amici Prism diag. for correct left-right views	**$59.50**

2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for Criterion 4000, 8000	**$26.00**
2" adapter for C-80, C-90, C-100	**$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F	**$39.50**
2" Accessory adapter for Comet Catcher*, C-6*, Meade 310, 320 refractor	**$30.00**
2" adapter for Takahashi E-130, 160	**$59.50**

COMA CORRECTOR MULTIPLIER - 2" BARLOW

These custom-designed LUMICON lenses correct aberrations in f/4 to f/5 Newtonians, and thread directly into LUMICON 2" Easy-Guiders. The LUMICON Coma Corrector/Field Flattener improves photographic star images for fast Newtonian telescopes by correcting coma and flattening the field. Off-axis star images are much smaller, making off-axis guiding easier, and reducing the off-axis star image size in photos. The LUMICON Multiplier/Field Flattener multiplies the image scale by 1.8X (f/4.5 becomes f/8) with the included extension tube (1.5X w/o extension). The multiplier may also be used visually as a highly corrected 2" Barlow lens. Lens designs are optimized for f/4.5 and all surfaces are multi-coated.

48mm Coma Corrector/Field Flattener	**$285.00**
1.5X/1.8X Multiplier/Field Flattener	**$195.00**
LUMICON 2" Easy-Guider (St. camera)	**$169.50**

VIEWING ADAPTERS

2"/1¼" Adapter, threaded 48mm filters	**$20**
2"/T - Thread adapter, threaded 48mm	**$25**
T - Thread/1¼" adapter. Converts telephoto lenses for viewing as finderscopes	**$25**

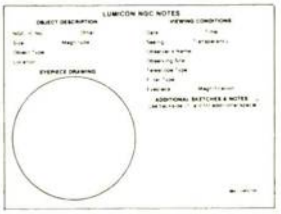
EXTENSION TUBES

1.0" long Thread-in extension tube	**$12.00**
1-2½" long, threaded for 1¼" filters	**$16.00**
4½" long extension tube, 1¼" i.d.	**$25.00**
2" i.d. Extension tube, 3" long, threaded for 48mm filters, adds 1.6-3.0"	**$26.00**

48mm COLORED GLASS FILTERS

These 48mm Filters thread into LUMICON EASY-GUIDERS and most 2" eyepieces. Use adapter for 1¼" eyepieces. AR Coated.

Filter:	Bandpess	Trans	Price
Ultraviolet	320-420nm	85%	**$35**
Minus Violet	420nm-IR	96%	**$29**
Blue Tricolor	340-470nm	80%	**$35**
Hi Perf. Blue	300-540nm	95%	**$35**
Yellow	480nm-IR	98%	**$18**
Green	490-590nm	60%	**$18**
Orange	560nm-IR	98%	**$18**
Red	600nm-IR	98%	**$18**
H-Alpha Pass	640nm-IR	95%	**$35**
Cyan	340-580nm	95%	**$59**



NGC NOTES

These handy **NGC NOTES** are stiff 4"X5½" cards. the **NGC NOTES** fit in your hand and are ideal for making notes and sketches while observing at the eyepiece. Making sketches **greatly improves** your observing skills and also gives you a permanent record. Get 200 **NGC NOTES** for Messier objects; NGC object observers should get 400-800 **NGC NOTES.**

NGC NOTES, Pack of 200	**$9.95**
Pack of 400 **$17.95** Pack of 800	**$32.95**

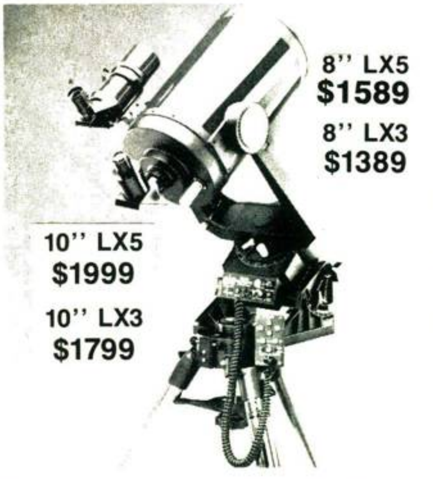
Meade® TELESCOPES AT LUMICON

New Meade MTS telescopes in stock!
6" f/4 $595, 8" f/4 $895, 8" SCT $895, 10" SCT $1495
Call for details on available options for MTS telescopes

NEW! 2080/LX5 w/MCOG $1589
MEADE 2120/LX5 w/MCOG . . . $1999

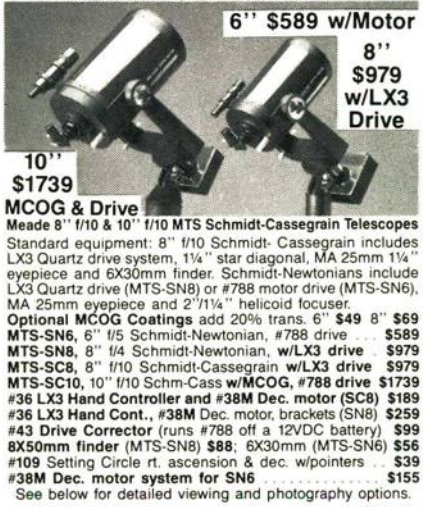
The most advanced Schmidt-Cassegrain telescope available! *Standard equipment* includes dual-axis hand-held electronic command center, 2" mirror star diagonal, 9X60mm polar viewfinder, multi-coated/enhanced optics, 26mm Super Plossl, tripod and wedge.

#39 Electric declination for 2080 or 2120/LX5	**$109**
Dew shield-essential 8" (#712) **$65**; 10" (#710)	**$98**
Accessory shelf for field tripod ($40 list)	**$28**
LUMICON EASY-GUIDER/Rich-Field viewer: for 2080 (f/6 operation) **$225**; for 2120 (f/4-f/10 operation)	**$395**
Computer control system, 8000 object memory	**$1495**



Meade 8" Model 2080/LX5: Shown with *standard-equipment* 9X60mm finder, dual-axis controller, 2" Diagonal Mirror, Equatorial Wedge, Field Tripod.

NEW! MTS TELESCOPES



Meade 8" f/10 & 10" f/10 MTS Schmidt-Cassegrain Telescopes

Standard equipment: 8" f/10 Schmidt- Cassegrain includes LX3 Quartz drive system, 1¼" star diagonal, MA 25mm 1¼" eyepiece and 6X30mm finder. Schmidt-Newtonians include LX3 Quartz drive (MTS-SN8) or #788 motor drive (MTS-SN6), MA 25mm eyepiece and 2"/1¼" helicoid focuser.

Optional MCOG Coatings add 20% trans. 6" **$49** 8"	**$69**
MTS-SN6, 6" f/5 Schmidt-Newtonian, #788 drive	**$589**
MTS-SN8, 8" f/4 Schmidt-Newtonian, **w/LX3 drive**	**$979**
MTS-SC8, 8" f/10 Schmidt-Cassegrain **w/LX3 drive**	**$979**
MTS-SC10, 10" f/10 Schm-Cass **w/MCOG, #788 drive**	**$1739**
#36 LX3 Hand Controller and #38M Dec. motor (SC8)	**$189**
#36 LX3 Hand Cont., #38M Dec. motor, brackets (SN8)	**$259**
#43 Drive Corrector (runs #788 off a 12VDC battery)	**$99**
8X50mm finder (MTS-SN8) **$88**; 6X30mm (MTS-SN6)	**$56**
#109 Setting Circle rt. ascension & dec. w/pointers	**$39**
#38M Dec. motor system for SN6	**$155**

See below for detailed viewing and photography options.

4" MEADE 2045 w/table tripod $595

4" f/10 Meade 2045/LX3 w/quartz drive	**$795**
#36 dual-axis cont. (LX3) **$99,** #38A dec. motor	**$99**
Wedge & field tripod for Meade 2045 ($380 list)	**$298**
Dew shield ($80 list) **$55;** Solar Filter	**$95**

FILTERS STOP POLLUTION

LUMICON UHC Filter™ for nebulae. Standard 1¼"	**$79**
Prem 1¼" **$99;** Std 48mm **$159.50;** Prem 48mm	**$199.50**
LUMICON Deep-Sky Filter™, 1¼" Premium	**$79**
48mm Prem Deep-Sky **$119.50, $99.95** w/Easy-Guider	
Adapter for viewing w/1¼" eyepiece	**$20**

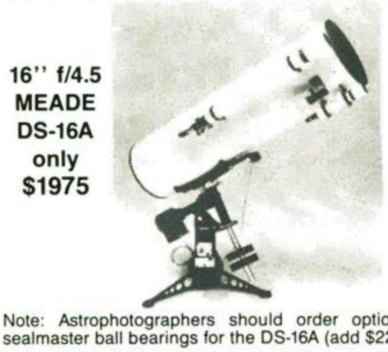
PHOTOGRAPHY ACCESSORIES

LUMICON Newtonian Easy-Guider, 1¼" or 2"	**$169**
LUMICON Cassegrain EASY-GUIDER for Meade 2045, 2080/LX5 and 2080/GEM (state camera)	**$225**
Illuminated reticle eyepiece & battery pack	**$89.50**
Dual-axis Drive corrector	**$219**

These Meade Telescopes are complete and ready for viewing.

They include telescope with all coated optics for high transmission, mount, tripod or pier with legs, motor drive (except models 6600, 8800, GEM series). Finderscope, at least one eyepiece, and complete instructions. Call or write LUMICON for full technical information. MCOG means multi-coated enhanced optics group.

MEADE NEWTONIAN TELESCOPES



Note: Astrophotographers should order optional sealmaster ball bearings for the DS-16A (add $229).

Model 6600, 6" f/5 w/1¼" focuser, 6X30 finder	**$685**
Model 628c, 6" f/8 w/motor, 2" focuser, 8X50 finder	**$798**
Model 645c, 6" f/5 w/motor, 2" focuser, 8X50 finder	**$829**
Model 8800, 8" f/4.5 w/1¼" focuser, 6X30 finder	**$895**
Model 826c, 8" f/6 w/motor, 2" focuser, 8X50 finder	**$975**
Model DS-10A, 10" f/4.5 w/motor, 2" focuser	**$995**
Model DS-16A, 16" f/4.5 w/motor, 2" focuser	**$1975**
Sealmaster ball bearings for DS-16A, recommended!	**add $229**
Finderscope for DS-10A, DS-16A, 8X50mm incl. mount	**$109**

All foreign orders add 6% ($8 minimum). California residents add 6% tax. Prices subject to change w/o notice. Set Meade and LUMICON Catalogues $4. **LUMICON, 2111 Research Dr., #5, Livermore, CA 94550.** Call **(415) 447-9570** for information & orders. Store Hours: M-F 9am-5pm; Sat 11am-3pm. All telescopes shipped F.O.B. Livermore.

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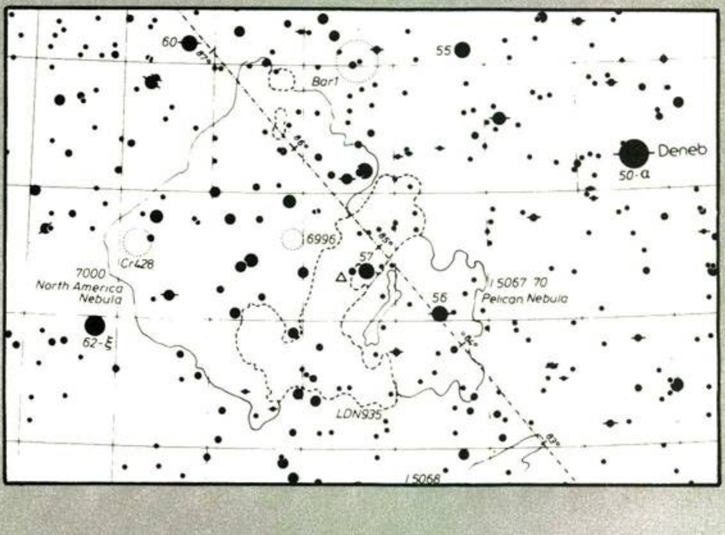
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This superb 3.1" refractor with precision altazimuth mount is great for the beginner and advanced amateur. Includes Celestron 26mm Plossl eyepiece.

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Celestron Comet Catcher **$419**
Fast f/3.6 optics for brilliant deep sky viewing and astrophotography. Includes 18mm Orthoscopic eyepiece and tripod adapter block.

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The complete 1000mm telephoto lens package for great photography. With a free star diagonal, eyepiece holder, and 25mm eyepiece for sharp viewing.

Accessories for Meade LX-5

#39 Declination motor	$89
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Tube Balance System	$99
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8" Dew Shade	$59
10" Dew Shade	$99
8" Solar Filter	$129
10" Solar Filter	$149
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Complete 10" deep space reflector with clock drive.

Tele Vue Renaissance with Ash Systems Mount **$1949**
Precision optics and a beautiful showpiece. Solid brass 4" telescope with natural finish ash tripod, systems mount, adapter plate, and extra balance weight. Includes 2" star diagonal, 1.25" adapter, and one Plossl eyepiece (7.4-26mm).

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ASTRONOMY's 1988 Summer Guide

Astronomy in the

Summer was made for amateur astronomers. Sharing your hobby with others at all-night star parties and national conventions, visiting observatories and planetariums that focus on astronomy and space, and looking up at the night sky in solitude — there's a multitude of options to choose from this summer.

A Stellar Lineup of Summer Events

The bright Sun, the gentle breeze, and the intensely green world around you announce that summer is here once again. Somehow life seems slower, more relaxed. But for amateur astronomers summer offers so many activities to get involved in that you'll have a tough time deciding how you're going to enjoy the clement weather.

Along with comfortable conditions for sitting back and looking up at the universe around you, summer provides countless opportunities to meet other amateur astronomers at national and regional meetings and star parties. There are Spaceweek celebrations planned around the country and museums, planetariums, and observatories to visit in your hometown and on your summer vacation.

We've collected the highlights of summertime astronomy activities for you. For more details on these events, contact the sponsors given below. The addresses and phone numbers of the sponsors are listed alphabetically in the Summer 1988 Directory of Astronomical Groups and Places on pages 63-73. Take a look and make your choices, you've got the whole summer ahead to enjoy!

National and International Amateur Meetings

ALCON, the annual convention of the Astronomical League, provides the opportunity for amateur clubs that belong to the Astronomical League to get together. Held July 27-30, this year's convention is hosted by the Omaha Astronomical Society in Omaha, Nebraska. (Contact the Omaha group for details.) The annual convention of the Association of Lunar and Planetary Observers of San Francisco, California, will be held at the same time. An observing workshop, exhibits, and papers will be presented.

Another annual meeting will be held at the National Radio Astronomy Observatory in Green Bank, West Virginia, when the Society of Amateur Radio Astronomers, Inc., meets June 13-15. The society has three hundred members worldwide, who are involved in many individual projects including searches for

Summertime

extraterrestrial intelligence. Contact the society in Tampa, Florida, for details about the meeting.

For Canadian amateurs, the Royal Astronomical Society of Canada — Quebec Centre is sponsoring the **Thirteenth Annual Association des Groupes d'Astronomes Amateurs Congress**, June 17-19. The congress is sponsored by the Quebec Centre of Sainte-Foy.

Get acquainted with amateur astronomers from across the United States and Canada at **Universe '88**, the joint meeting of the Astronomical Society of the Pacific, the Western Amateur Astronomers, and the Royal Astronomical Society of Canada, which will be held at the University of Victoria in Victoria, British Columbia.

This is the one hundredth annual meeting of the Astronomical Society of the Pacific. From June 25 to July 2, there'll be papers presented by professional and amateur astronomers, a scientific symposium on the extragalactic distance scale, and nontechnical talks by professional astronomers. A special exhibit area will be set up for telescopes, astronomical computer software, and other astronomical products, and tours of the Dominion Astrophysical Observatory and other local sights will be arranged. Contact the Astronomical Society of the Pacific in San Francisco, California, for details.

The 'Big Three' Star Parties

The summer's most famous star parties draw astronomers from across the country and even from abroad. While each of these star parties offers something distinctive to amateur astronomers, they are all ideal settings for getting to know others who share your hobby. Around 1,500 telescope makers flock to the three-day **Riverside Telescope Makers Conference** at Camp Oakes, Big Bear, California, to check out the latest in telescope creations, trade telescope-making tips and techniques, and buy new or second-hand equipment from commercial exhibitors. The twentieth Riverside conference is scheduled for May 27-30.

Stellafane, held in Springfield, Vermont, takes place on August 13. The biggest and the oldest of the summer star parties, Stellafane features home-built telescopes, observing, and guest lecturers and attracts about two thousand people each year.

The dark skies of Fort Davis, Texas, will lure about five hundred amateurs to the **Texas Star Party** May 8-15. Featured activities include observing, astrophotography, speakers, swap meets, and giveaways.

Regional Astronomical Events

Close to home you'll also find opportunities to get together with fellow amateur astronomers. Many regional events center around a star party, which involves staying up all night to soak up every possible sight in the night sky before morning breaks. And what better way to make new friends than by exploring the mysteries of the universe with others who are as awed by what they see as you are?

If you live on the East Coast or are traveling there this summer, spend the day at **Star-Conn II**, sponsored by the Astronomical Society of Greater Hartford in West Hartford, Connecticut. A day-long series of presentations plus evening speakers at Wesleyan University in Middletown, Connecticut, and observing at Van Vleck Observatory are featured at this event in June. Or stop by **Astrofest '88** in Vestal, New York, sponsored by the Broome County Astronomical Society at the Roberson-Kopernick Observatory.

An annual celebration to commemorate the birthday of Maria Mitchell, the first American woman professional astronomer, will feature open houses at the Maria Mitchell Observatory (usually closed to the public) and Loines Observatory in Nantucket, Massachusetts, in

Illustration by Todd Graveline

early August. If the sky is clear, the celebration will include observing Venus or sunspots during the day. Contact the observatories for details.

The astronomical societies in Virginia will convene at the **Fourteenth Virginia Association of Astronomical Societies Convention** in Tidewater on May 14. Lectures, an equipment swap shop, competitions, and a star party are sponsored by the Back Bay Amateur Astronomers of Chesapeake.

Astrophotographers will find two events in South Carolina this summer of interest. Both are sponsored by the Carolina Skygazers Astronomy Club of Rock Hill. The **Amateur Astronomers/Astrophotographers Convention** will be held July 1-3. **Heavens Above!**, an astrophotography exhibit that opens July 1, will feature work by Johnny Horne, Howard Brewington, and other accomplished astrophotographers. This exhibit is cosponsored by the Museum of York County/Settlemyre Planetarium.

For those of you in the Midwest, there's an assortment of regional star parties, telescope fairs, and campouts in Ohio, Michigan, Illinois, and Minnesota. The **Seventeenth Annual Apollo Rendezvous and Telescope Fair**, sponsored by the Dayton Museum of Natural History in Dayton, Ohio, takes place June 10-11. About two hundred people from around the Midwest gather for the astronomical flea market, commercial and participant displays, and speakers. You can also enter your telescope in the telescope fair and see the latest telescope designs entered by others.

On July 16, the **Chagrin Valley Astronomical Society Convention** of Chagrin Falls, Ohio, will be held at Indian Hill Observatory in Huntsburg, Ohio. And scheduled for August is the **Ohio Turnpike Astronomers Association Convention**, sponsored by the Astronomy Club of Akron, Inc.

Speakers, workshops, displays, and observing are featured at the **North Central Astronomical League Regional Convention**, sponsored by the the Marquette Astronomical Society of Marquette, Michigan, May 13-15.

Two major events are planned in Illinois this summer. The **Astronomy Rendezvous and Conference**, hosted by the Twin City Amateur Astronomers of Normal, will take place at Illinois State University, August 12-14. Planetarium programs, a telescope display, a computer demonstration, an astronomy flea market, amateur and commercial exhibits, plus papers fill the schedule. Contact the Illinois State University Planetarium for details. The Northwest Suburban Astronomers of Barrington will sponsor the **Third Annual Wildcat Mountain Astronomy Campout**, August 5-14. You can look forward to observing, canoeing, biking, and hiking in western Wisconsin at this event.

Amateurs in Minnesota will gather for the **Annual Minnesota Valley Amateur Astronomers Southern Minnesota Sky Show**, sponsored by the Minnesota Valley Amateur Astronomers of New Ulm on June 4, and amateurs in Iowa get together for the **All Iowa Star Party**, sponsored by the Southeastern Iowa Astronomy Club of Burlington, May 13-15.

In the Pacific Northwest the **Summer Star Party** at the Pine Mountain Observatory east of Bend, Oregon, will bring together the OMSI Astronomers of Portland and others in the area on July 9. Contact the OMSI Astronomers for details.

The **Arkansas Star Party** will be held June 10-11 at the Douglas C. Coleman Memorial Observatory, south of Fort Smith, Arkansas. It is sponsored by the Arkansas—Oklahoma Astronomical Society of Pocola, Oklahoma.

Amateur Events in Canada

In addition to the Astronomical Society of the Pacific and the Royal Astronomical Society meetings this summer, there are also four regional star parties in Canada. The **Alberta Star Party**, hosted by the Royal Astronomical Society of Canada — Edmonton Centre, will be held at Dinosaur Province Park in southern Alberta. The whole family is invited to talks on the Nemesis theory of extinction of the dinosaurs and amateur astronomy presentations, which take place August 19-21; preregistration is required.

The fifth annual **Mount Kobau Star Party** in Okanagan Valley, British Columbia, boasts a pastoral mountain setting and dark, clear skies. Sponsored by the Okanagan Astronomical Society of Vernon, British Columbia, August 10-14, the star party features observing, telescope-making and astrophotographic contests, and speakers. Last year's star party drew two hundred people from Canada and the United States.

Nova East '88 is a joint star party of the Royal Astronomical Society of Canada—Halifax, Nova Scotia, and Saint John, New Brunswick, centres, which will be held at Fundy National Park, New Brunswick, August 12-15. Contact the Halifax Centre for details.

Rounding out the regional Canadian meetings is **Starfest '88**, sponsored by the North York Astronomical Association of Toronto, Ontario. The seventh annual observing convention will be held at the River Place Campground north of Mount Forest, Ontario, and will feature slide presentations, talks, workshops, and commercial displays August 5-6.

Activities for Space Fans

Every year since 1980, the anniversary of the *Apollo 11* mission, July 16-24, has been set aside as Spaceweek to commemorate mankind's exploration of space. Spaceweek, Inc., chartered by the State of Texas, oversees a national program of celebrations that focus public attention on the benefits and potentials of space exploration. Along with the Spaceweek activities listed here, be sure to check with astronomical and space groups in your area for other activities.

In Pennsylvania the **National Spaceweek Observation** is sponsored by the L5 Philadelphia Chapter of the National Space Society of Lansdale. The Orion Research Forum and Network of Knoxville, Tennessee, will also sponsor a celebration of the space program. In Louisiana, Spaceweek activities will be sponsored by the Lafayette Natural History Museum and Planetarium in Lafayette.

Summer Sky Events

Along with special meetings and star parties, every summer offers astronomical events in the sky for amateur astronomers to observe. There are annual events like the Perseid meteor shower (August 12) and special events like this summer's apparition of Mars, which is the best in seventeen years. Be sure to contact the astronomical clubs in your area for their summer observing programs.

To celebrate the summer solstice, the Discovery Center of Science and Technology in Syracuse, New York, offers the third annual **Great Snowball Melt** in conjunction with opening the summer planetarium program, "Summer Star Watch," on June 18. Activities include making the biggest snowball (with snow stored in the freezer) and solar observing if the day is clear. Several hundred people turn out for the event each year.

It doesn't matter whether you travel this summer or stay in your own backyard, the sky's always there for you to enjoy. Don't forget to take a few hours out of your busy summer schedule to just look up.

— Kristine R. Majdacic

Summer 1988 Directory of Astronomical Groups and Places

Take Your Turn at an Antique Telescope **Observe through the historic Alvan Clark 12-inch refractor on Monday evening tours of the U.S. Naval Observatory in Washington, D.C. Restored in 1980, the nineteenth-century instrument is equipped with both the original and modern eyepieces.**

ALABAMA

Auburn

Auburn Astronomical Society. 1963 Canary Drive, 36830. Rhonald M. Jenkins.

Birmingham

Birmingham Astronomical Society. 1425 22nd Street, 35205. Emmie Longshore, (205) 933-8422.

Robert R. Meyer Planetarium. Birmingham Southern College, 35254. (205) 226-4770. Exhibits, lectures, planetarium shows, special children's programs. Open Monday-Friday and Sunday.

Huntsville

Marshall Space Flight Center. 35812. (205) 544-0034.

Tuscumbia

Muscle Shoals Astronomical Society. 302 NE Commons, 35674. Homer Russell, Jr., (205) 383-6717.

ALASKA

Anchorage

Anchorage Astronomical Society. 3539 Dunkirk Drive, 99502. John Morrow, (907) 269-5744.

Fairbanks

Geophysical Institute. University of Alaska-Fairbanks, Elvey Building, 99775. (907) 474-7598.

ARIZONA

Flagstaff

Barringer Meteor Crater. Forty miles east of Flagstaff. Meteor Crater Enterprises, 121 East Birch, 86001. (602) 774-8350.

Lowell Observatory. 1400 West Mars Hill Road, 86001. Paul Roques, (602) 635-9272. Exhibits, historical astronomical instruments, tours, lectures, public observing, open houses. Open Tuesday-Saturday.

Northern Arizona University Campus Observatory. Department of Physics and Astronomy, 86011. Andrew P. Odell, (602) 523-2661.

Gilbert

Saguaro Astronomy Club. 5 South Pueblo Street, 85234. Gerald W. Rattley, (602) 892-5698.

Scottsdale

Phoenix Astronomical Society. 6945 East Gary Road, 85254. Raul V. Espinoza, (602) 948-3617.

Tucson

Flandrau Planetarium. University of Arizona, Corner of Cherry and University Boulevard, 85721. Raymond Shubinski, (602) 621-4515. Exhibits, historical astronomical instruments, public observing, planetarium shows, observatory, special children's programs. Open Tuesday-Sunday.

Kitt Peak National Observatory. Box 26732, 85726-6732. (602) 325-9204.

Steward Observatory. University of Arizona, 85721. (602) 621-2288.

Tucson Amateur Astronomy Association. 7222 East Brooks Drive, 85730. Terri Lappin.

ARKANSAS

Ashdown

Ark-La-Tex Sky Watchers. Route 2, Box 9, 71822. Walter Webb, (501) 898-3178.

Little Rock

Mid-South Astronomical Society. P.O. Box 5142, 72205. James (Bruce) McMath, (501) 376-3021.

CALIFORNIA

Altadena

Polaris Astronomical Society. 228 East Pentagon Street, 91001. Rick Shaffer, (818) 797-2845.

Berkeley

Lawrence Hall of Science. University of California, 94720. Barbara Ando, (415) 642-5134. Exhibits, classes, public observing, films, planetarium shows, special children's programs. Open Monday-Sunday.

Big Bear

Riverside Telescope Makers Conference. Camp Oakes. Contact Cliff Holmes, 8642 Wells Avenue, Riverside, CA 92503. (714) 689-6893.

Stony Ridge Observatory. P.O. Box 874, 92314. Tony Heinzman, (714) 585-5486.

Corona

Riverside Astronomical Society. 413 West Kendall, 91720. Tom Fangrow, (714) 735-2068.

Cucamonga

Pomona Valley Amateur Astronomers. 8773 Balsa Street, 91730. Bob Hibble, (714) 989-3680.

Edwards

Ames Research Center. Hugh L. Dryden Flight Research Facility, 93523. (805) 258-3446.

Fresno

Central Valley Astronomers. The Discovery Center, 1944 North Winery Avenue, 93703.

The Discovery Center. 1944 North Winery Avenue, 93703. (209) 251-5533.

Hayward

Astrosoft. P.O. Box 4451, 94550-4451. Martin E. Morrison, (415) 278-8458.

Idyllwild

Idyll-Gazers Amateur Astronomy Club. P.O. Box K, 92349. Joe Neu, (714) 659-3562.

Los Angeles

Griffith Observatory. 2800 East Observatory Road, 90027. John Mosley, (213) 664-1191. Exhibits, lectures, public observing, planetarium shows, laser shows, special children's programs. Open Tuesday-Sunday, after July 1 also open Monday.

Los Angeles Astronomical Society. 2800 East Observatory Road, 90027. Tom Dorff, (213) 926-4071.

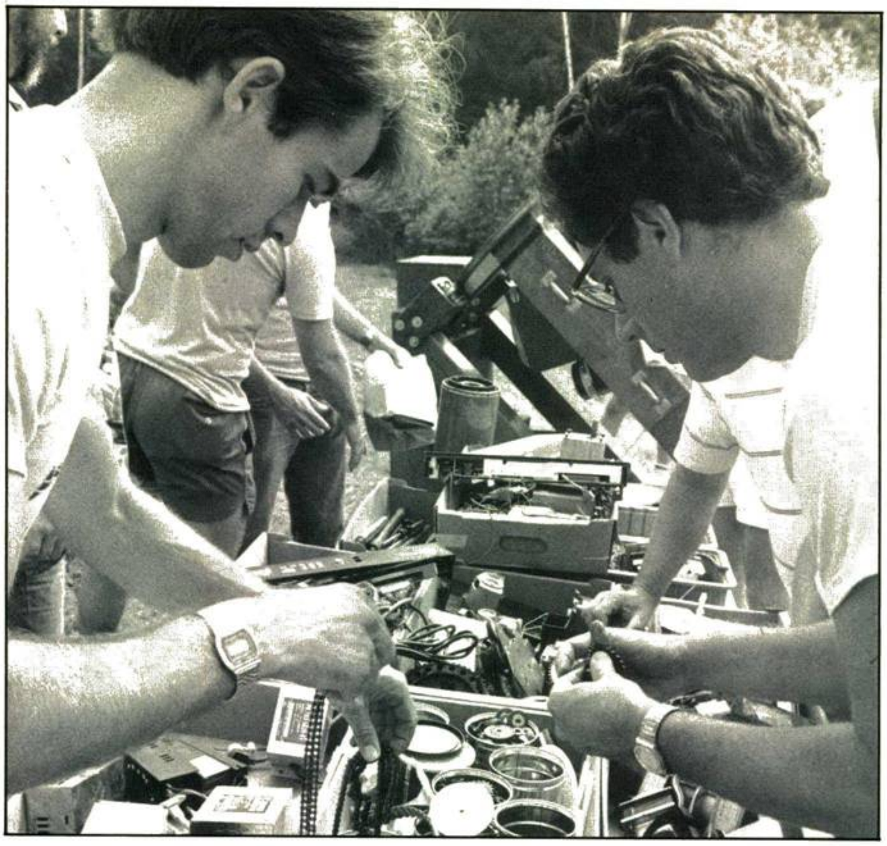
Problicom Sky Survey and Nova Patrol. 1940 Cotner Avenue, 90025. Ben Mayer, (213) 478-2526.

Moraga

Astronomical Association of Northern California. 731 Camino Ricardo, 94556. Don Stone, (415) 376-3007.

Mount Hamilton

Lick Observatory. 95140. (408) 274-5062. Visitor's gallery open Monday-Sunday, rest of observatory closed because of repairs.



Hand-Picked 'Finds' at Summer Star Parties If you're willing to dig for your treasures, swap meets are for you. At Stellafane, held in Springfield, Vermont, amateur astronomers rummage through the used equipment others bring to the annual star party. Photo by Richard Berry.

Mountain View

Peninsula Astronomical Society. P.O. Box 4542, 94040. Bill Sorrells, (415) 566-3116.

Orange

Orange County Astronomers. 2215 Martha Avenue, 92667. John Sanford, (714) 639-8446.

Palm Desert

Astronomical Society of the Desert. College of the Desert, 45-300 Monterey Avenue, 92260. Ashley McDermott, (619) 346-8041.

Palomar Mountain

Palomar Observatory. 92060.

Pasadena

Asteroid Project. World Space Foundation, P.O. Box Y, 91030-1000. Jack Child, (818) 799-5135.

Jet Propulsion Lab. 4800 Oak Grove, 91109. (818) 354-7006.

Pleasant Hill

Diablo Valley College. 321 Golf Club Road, 94523. Robert Searls, (415) 685-1230. Classes, planetarium shows, observatory, open houses. Open Monday-Friday.

Redding

Schreder Planetarium. 1644 Magnolia Avenue, 96001. Kenneth Adams, (916) 244-4600. Planetarium shows. Open Friday evenings.

Rohnert Park

Sonoma State University. Department of Physics and Astronomy, 94928. Gordon Spear, (707) 664-2267. Public observing, observatory. Open monthly.

Salinas

Space Frontier Society of the Monterey Bay Area. P.O. Box 9382, 93915-9382. Oscar G. Garcia, (408) 757-2725.

San Bernardino

San Bernardino Amateur Astronomers. 1345 Garner Avenue, 92411. David Garcia, (714) 884-0657.

San Diego

Reuben H. Fleet Space Theater and Science Center. 1875 El Prado, Balboa Park, 92101. Mary Hettinger, (619) 238-1233. Exhibits, lectures, classes, films, planetarium shows, laser shows, OMNIMAX theater, special children's programs. Open Monday-Sunday.

Mount Laguna Observatory. Department of Astronomy, San Diego State University, 92182. Burt Nelson, (619) 265-6175.

San Francisco

Association of Lunar and Planetary Observers. P.O. Box 16131, 94116. John Westfall, (415) 566-5786. Cosponsors ALCON '88.

Astronomical Society of the Pacific. 1290 24th Avenue, 94122. (415) 661-8660. Sponsors Universe '88.

Exploratorium. 3601 Lyon Street, 94123. Linda Dachman, (415) 563-7337. Exhibits, historical astronomical instruments, films, laser shows. Open Wednesday-Sunday.

Morrison Planetarium. California Academy of Sciences, Golden Gate Park, 94118. Elizabeth Keough, (415) 750-7141. Exhibits, planetarium shows, laser shows. Open Monday-Sunday.

San Francisco Amateur Astronomers. Morrison Planetarium, California Academy of Science, Golden Gate Park, 94118. Irving Hochman, (415) 641-0770.

San Francisco Sidewalk Astronomers. 1600 Baker Street, 94115. John Dobson, (415) 567-2063.

San Jose

San Jose Astronomical Association. 3509 Calico Avenue, 95124. Jim Van Nuland, (408) 371-1307.

San Juan Bautista

Fremont Peak Observatory Association. Fremont Peak State Park, P.O. Box 1110, 95045. Denni Medlock, (415) 654-6796.

San Luis Obispo

Central Coast Astronomical Society. P.O. Box 1415, 93406. Lee Coombs, (805) 528-6682.

Santa Barbara

Santa Barbara Museum of Natural History. 2559 Puerta del Sol Road, 93105. Kay Woolsey, (805) 682-4711. Exhibits, classes, public observing, planetarium shows, observatory, special children's programs. Open Monday-Sunday.

Santa Monica

Santa Monica City College Planetarium. 1900 Pico Boulevard, 90405. Jonathon Hodge, (213) 452-9223. Exhibits, lectures, classes, public observing, planetarium shows, observatory, special children's programs. Open Friday evenings.

Santa Rosa

Santa Rosa Junior College Planetarium. 1501 Mendocino Avenue, 95472. Ronald Oriti, (707) 527-4365. Exhibits, lectures, classes, public observing, planetarium shows, special children's programs. Open Friday and Saturday evenings.

Sonoma County Amateur Astronomers. P.O. Box 183, 95402. Robert Ferguson, (707) 762-2064.

Simi Valley

Ventura County Astronomical Society. P.O. Box 982, 93062. Hal Jandorf, (805) 529-3984.

Tulare

Tulare Astronomical Association. P.O. Box 515, 93275-0515. Stanley H. Manro, (209) 686-6836.

Walnut Creek

Mount Diablo Astronomical Society. 1725 Sunnyvale Avenue, 94596. Paul H. Cragey, (415) 676-6046.

Woodland Hills

Polaris Astronomical Association. 22018 Ybarra Road, 91364. Ray G. Coutchie, (818) 347-8922.

COLORADO

Boulder

Fiske Planetarium and Science Center. University of Colorado, 80309-0408. Gene Ammarell, (303) 492-5001. Exhibits, tours, lectures, classes, public observing, planetarium shows, laser shows, observatory, special children's programs. Open Monday-Friday.

Colorado Springs

U.S. Air Force Academy Planetarium. 50 ATS/DOP, USAFA, 80840. James McBride, (303) 472-2779. Lectures, classes, planetarium shows, special children's programs. Open Tuesday-Sunday and by reservation.

Denver

Denver Astronomical Society. P.O. Box 10814, 80210. Ivan Geisler, (303) 431-6218.

Longmont

Longmont Astronomical Society. P.O. Box 8086, 80501. Bob Spohn, (303) 772-1470.

CONNECTICUT

Danbury

Western Connecticut State University. 06810. Philip K. Lu, (203) 797-4218. Exhibits, tours, lectures, classes, public observing, planetarium shows, observatory, open houses. Open by reservation only.

New Britain

Copernican Observatory and Planetarium. Central Connecticut State University, Wells Street, 06050. Craig Robinson, (203) 827-7852. Planetarium shows. Open Friday and Saturday evenings.

Stamford

Stamford Museum and Nature Center. 39 Scofieldtown Road, 06903. Davis Mitchell, (203) 322-1646. Exhibits, space artifacts, tours, lectures, public observing, planetarium shows, observatory. Open Monday-Sunday.

Waterbury

Mattatuck Astronomical Society. Mattatuck Community College, 750 Chase Parkway, 06708. Michael Carlone, (203) 575-8065.

West Hartford

Astronomical Society of Greater Hartford. Gengras Planetarium, 950 Trout Brook Drive, 06119. Jay Sottolano, (203) 651-0096. Sponsors Star-Conn II.

Gengras Planetarium. Science Museum of Connecticut, 950 Trout Brook Drive, 06119. Francis J. Downey, (203) 236-2961.

DELAWARE

Greenville

Delaware Astronomical Society. Mount Cuba Astronomical Observatory, P.O. Box 3915, Hillside Mill Road, 19807.

Mount Cuba Planetarium and Astronomical Observatory. P.O. Box 3915, Hillside Mill Road, 19807. Leo G. Glasser, (302) 654-6407.

DISTRICT OF COLUMBIA

Albert Einstein Planetarium. National Air & Space Museum, Smithsonian Institution, 6th Street and Independence Avenue SW, 20560. James H. Sharp, (202) 357-1529. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, public observing, films, planetarium shows, IMAX theater, open houses, special children's programs. Open Monday-Sunday.

U.S. Naval Observatory. 34th and Massachusetts Avenue NW, 20392. Public Affairs Office, (202) 653-1543. Historical astronomical instruments, tours, public observing. Open Monday evenings.

FLORIDA

Bradenton

Bishop Planetarium. 201 10th Street West, 34205. John Hare, (813) 746-4132. Exhibits, classes, public observing, planetarium shows, laser shows, observatory. Open Tuesday-Sunday.

Local Group of Deep-Sky Observers. 2311 23rd Avenue West, 34205. Vic and Lynne Menard, (813) 747-8334.

Cocoa

Astronaut Memorial Hall. 1519 Clearlake Road, 32922. Mike Hutton, (305) 632-1111. Exhibits, space artifacts, public observing, films, planetarium shows, laser shows, observatory, special children's programs. Open Monday-Saturday.

Daytona Beach

Museum of Arts and Sciences Planetarium. 1040 Museum Boulevard, 32014. Lee Golden, (904) 255-0285. Exhibits, planetarium shows, laser shows, special children's programs. Open Tuesday-Saturday.

Fort Myers

Junior Museum and Planetarium of Lee County. P.O. Box 06023, 33906. June Payne, (813) 275-3183. Exhibits, tours, lectures, classes, public observing, films, planetarium shows, special children's programs. Open Wednesday-Sunday.

Jacksonville

Alexander Brest Planetarium. Jacksonville Museum of Science and History. 1025 Gulf Life Road, 32207. Barry Perlman, (904) 396-7062. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, public observing, films, planetarium shows, laser shows, special children's programs. Open Monday-Sunday.

Kennedy Space Center

NASA Kennedy Space Center's Spaceport USA. 32899. George Meguiar, (305) 452-2121. Exhibits, space artifacts, tours, lectures, public observing, films, IMAX theater, special children's programs. Open Monday-Sunday.

Key Biscayne

Southern Cross Astronomical Society, Inc. 690 Allendale Road, 33149. Barb Yager, (305) 661-1375.

Melbourne

Space Coast Science Center. P.O. Box 36-1816, 1510 Highland Avenue, 32936. Robert G. Tuck, Jr., (407) 259-5572. Exhibits, classes, open houses, special children's programs. Open Tuesday-Saturday.

Miami

Miami Space Transit Planetarium. 3280 South Miami Avenue, 33129. Jack F. Horkheimer, (305) 854-4242. Exhibits, space artifacts, lectures, classes, public observing, planetarium shows, laser shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Orlando

Central Florida Astronomical Society. 810 East Rollins Street, 32803. Timothy Printy, (305) 282-4547.

John Young Planetarium. Orlando Science Center, 810 East Rollins Street, 32803. Mike Murray, (305) 896-7151. Exhibits, public observing, planetarium shows, laser shows, observatory, special children's programs. Open Monday-Sunday.

Palm Beach

Astronomical Society of the Palm Beaches. 4801 Dreher Trail North, 33405. Gary M. Bogner, (305) 832-1988.

South Florida Science Museum and Aldrin Planetarium. 4801 Dreher Trail North, 33405. Gary M. Bogner, (305) 832-1988. Exhibits, space artifacts, lectures, classes, public observing, films, planetarium shows, laser shows, observatory. Open Monday-Sunday.

Pensacola

Astronomical League. 6235 Omie Circle, 32504. Merry Wooten, (904) 477-8732.

Escambia Amateur Astronomers' Association. Physical Sciences, Pensacola Junior College, 32504. John Wayne Wooten, (904) 476-5410 extension 1154.

St. Petersburg

St. Petersburg Astronomy Club, Inc. 594 59th Street South, 33707. Daniel W. Bricker, (813) 342-1594.

Tallahassee

Florida State University Planetarium. Richards Undergraduate Physics Laboratory Building, Atomic Drive, 32306. Vasken Hagopian, (904) 644-3734.

Tampa

Society of Amateur Radio Astronomers, Inc. P.O. Box 4208, 33677-4208. Sponsors annual meeting.

GEORGIA

Albany

Wetherbee Planetarium. 100 Roosevelt Road, 31701. Bob Dunagan, (912) 435-1572. Classes, planetarium shows, laser shows, special children's programs. Open by reservation only Monday-Friday and Sunday.

Athens

Athens Astronomical Association. 160 Plantation Drive, 30605.

Atlanta

Fernbank Science Center. 156 Heaton Park Drive NE, 30307. Loretta Honea, (404) 378-4311. Exhibits, space artifacts, lectures, classes, public observing, films, planetarium shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Columbus

Patterson Planetarium. 2900 Woodruff Farm Road, 31901. Carol Rutland Groce, (404) 568-1730. Lectures, classes, public observing, films, planetarium shows. Open Monday-Friday.

Macon

Mark Smith Planetarium and Observatory. 4182 Forsyth Road, 31210. Bill Peck, (912) 477-3232. Exhibits, lectures, classes, public observing, planetarium shows, laser shows. Open Monday-Sunday.

Rock Spring

Walker County Science Center/Planetarium. P.O. Box 10, Highway 95, 30739. Wayne Robinson, (404) 638-STAR.

Savannah

Savannah Science Museum. 4405 Paulsen Street, 31405. Vicki Psillos, (912) 355-6705. Exhibits, classes, planetarium shows, special children's programs. Open Tuesday-Sunday.

Valdosta

Valdosta State College Planetarium. Department of Physics, Astronomy, and Geology, 31698. Martha A. Leake, (912) 333-5756. Public observing, planetarium shows, observatory, open houses, special children's programs. By reservation only, Monday-Thursday.

Young Harris

Rollins Planetarium. Young Harris College, 30582. James R. Westlake, Jr., (404) 379-3990. Public observing, planetarium shows, laser shows. Open Friday.

HAWAII

Captain Cook

Mauna Kea Astronomical Society. RR1, Box 525, 96704. Howard T. Yamasaki, (808) 328-9201.

Hilo

Mauna Kea Observatory. 177 Makaala Street, 96720. (808) 935-3371.

Honolulu

Bishop Museum Planetarium. 1525 Bernice Street, 96817. Ken Miller, (808) 847-3511. Exhibits, tours, public observing, planetarium shows, observatory. Open Monday-Saturday.

Hawaiian Astronomical Society. P.O. Box 17671, 96822. Kayoko Calef, (808) 531-4567.

Makawao, Maui

Maui Astronomy Club. 325 Olokani Street, 96768. Bob Bennett, (808) 572-1939.

IDAHO

Rexburg

Ricks College Planetarium. 83440. Ellis Miller, (208) 356-1910. Exhibits, classes, public observing, films, planetarium shows, observatory. By reservation only.

ILLINOIS

Barrington

Northwest Suburban Astronomers. 4960 Chambers Drive, 60010. Sponsors the Third Annual Wildcat Mountain Astronomy Campout.

Chicago

Adler Planetarium. 1300 South Lake Shore Drive, 60605. Martha Benaroya, (312) 322-0337.

Chicago Astronomical Society. P.O. Box 48540, 60648.

Museum of Science and Industry and Crown Space Center. 57th Street and Lake Shore Drive, 60637. Steve Bishop, (312) 684-1414. Exhibits, space artifacts, lectures, classes, OMNIMAX theater, special children's programs. Open Monday-Sunday.

DeKalb

Northern Illinois University. Physics Department Observatory, 60116. (815) 753-1772.

Evanston

Northwestern University. 2145 Sheridan Road, 60201. Melville P. Ulmer, (312) 491-5633.

Glenview

Space Science Explorer Post #998. 910 Glenwood Lane, 60025. Gretchen Trinklein, (312) 998-1627.

Joliet

Joliet Astronomical Society. Box 3893, 60435.

Libertyville

Lake County Astronomical Society. 603 Dawes Street, 60048. Jack Kramer, (312) 362-0959.

Midlothian

Sunsearch. 14400 Kolin Avenue, 60445. Steve H. Lucas.

Naperville

Naperville Astronomical Association. 910 Fairway #203, 60540. Ray Bright, (312) 369-3533.

Normal

Illinois State University Planetarium. Corner of College Avenue and School Street, 61761. Carl J. Wenning, (309) 438-2496. Public observing, planetarium shows, special children's programs. Monday and Wednesday by reservation only. Sponsors the 1988 Astronomy Rendezvous and Conference.

Twin City Astronomers, Inc. Illinois State University Planetarium, 61761. Sharon MacDonald, (309) 376-5021.

Peoria

Lakeview Museum of Arts and Science Planetarium. 1125 West Lake Avenue, 61614. Sheldon Schafer. Exhibits, classes, planetarium shows, special children's programs. Open Tuesday-Thursday (July), Saturday and Sunday.

Quincy

Quincy Astronomical Society. #22 Summer Creek, 62301. Brad Haubrich, (217) 222-8832.

River Grove

Cernan Earth and Space Center. Triton College, 2000 5th Avenue, 60171. Bart Benjamin, (312) 456-5815. Exhibits, space artifacts, lectures, public observing, planetarium shows, laser shows, open houses, special children's programs. Open Monday-Sunday.

Rock Island

Popular Astronomy Club, Inc. John Deere Planetarium, Augustana College, 61201. Paul R. Castle, (309) 786-6119.

Rockford

Rockford Amateur Astronomers, Inc. 6804 Alvina Road, 61103. Barry or Carol Beaman, (815) 962-6540.

Time Museum. 7801 East State Street, P.O. Box 5285, 61125. Dorothy Mastricola, (815) 398-6000. Exhibits, historical astronomical instruments, tours, lectures, public observing, films. Open Tuesday-Sunday.

St. Charles

Argonne Astronomy Club. 6N106 White Oak Lane, 60175. H. F. DaBoll, (312) 584-1162.

Sugar Grove

Fox Valley Sky Watchers. Wauhonsee Community College, Route #47, 60118. Mike Anderer, (312) 377-6141.

Urbana

Astronomical Society at the University of Illinois. 349 Astronomy Building, 61801. Michael Svec.

INDIANA

Evansville

Evansville Astronomical Society. P.O. Box 3474, 47733. Cathy Finch.

Koch Science Center and Planetarium. 411 SE Riverside Drive, 47713. Mitch Luman, (812) 425-2406. Exhibits, lectures, classes, planetarium shows, laser shows, special children's programs. Open Tuesday-Sunday.

Fort Wayne

E. C. Schouweiler Planetarium. St. Francis College, 2701 Spring Street, 46806. Robert Stoekley, (219) 432-3551 extension 278. Planetarium shows. Open July 9-16.

Fort Wayne Astronomical Society. P.O. Box 6004, 46896. Robert Crider, (219) 747-0774.

Greencastle

McKim Observatory. DePauw University, 46135. Howard L. Brooks, (317) 658-4505. Tours, public observing, open houses. Open by reservation only.

Marshall

Nature Center Planetarium. Turkey Run State Park, RR 1, Box 164, 47859. Marquita Manley, (317) 597-2654. Exhibits, lectures, public observing, planetarium shows, special children's programs. Open Monday-Sunday.

Terre Haute

Indiana State University Observatory. Department of Geology and Geography, 47809. Robert Howe, (812) 237-2444. Historical astronomical instruments, classes, public observing, films. Open Tuesday and Friday evenings.

IOWA

Ames

Ames Area Amateur Astronomers. 1208 Wilson Avenue, 50010. David Oesper, (515) 232-8705.

Burlington

Southeastern Iowa Astronomy Club. 610 Walnut, 52601. Jim Blair, (314) 753-2509. Sponsors the 1988 All Iowa Star Party.

Cedar Rapids

Cedar Amateur Astronomers, Inc. Ambroz Center, 2000 Mount Vernon Road, 52321. Doug Slauson, (319) 857-4698.

Cherokee

Sanford Museum Planetarium. 117 East Willow Street, 51012. Terry Walker. Planetarium shows. Open Monday-Sunday.

Davenport

Quad Cities Astronomical Society. P.O. Box 3706, 52808. Dana Taylor, (319) 322-2557.

Des Moines

Drake University. 50311. Dr. Staunton, (515) 271-3141. Lectures, public observing, observatory, open houses. Open Friday evenings July 1-August 15.

Science Center of Iowa. 4500 Grand Avenue, 50312. Morris Mason, (515) 274-4138. Exhibits, historical astronomical instruments, lectures, classes, planetarium shows, open houses. Open Monday-Sunday.

Waterloo

Grout Museum Planetarium. 503 South Street, 50701. Alinda Wengenroth, (319) 234-6357. Planetarium shows, special children's programs. Open Tuesday-Saturday.

KANSAS

Great Bend

Barton County Community College Planetarium. Bissells Point Road, 67530. Richard Cordaro, (316) 792-2701. Planetarium shows. By reservation only.

Greensburg

Pallasite Meteorite. The Big Well, 315 South Sycamore, 67054. Mary L. Keller, (316) 723-2261. Exhibits. Open Monday-Sunday.

Hutchinson

Kansas Cosmosphere and Space Center. 1100 North Plum, 67501. Ellen Walker, (316) 662-2305. Exhibits, space artifacts, tours, lectures, classes, public observing, films, planetarium shows, OMNIMAX theater, open houses, special children's programs. Open Monday-Sunday.

Topeka

Northeast Kansas Amateur Astronomers League. P.O. Box 951, 66601. Gary Hug, (913) 354-4479.

Wichita

Wichita Omnisphere and Science Center. 220 South Main Street, 67202. Jose Olivarez, (316) 264-3174. Exhibits, tours, planetarium shows, special children's programs. Open Tuesday-Sunday.

KENTUCKY

Berea

Weatherford Planetarium. Berea College, CPO 1630, 40404. Smith Powell, (606) 986-9341 extension 6246. Public observing, planetarium shows, observatory. Open Saturday and Sunday evenings.

Louisville

Kentucky L5 Society. 802 Alden Road, 42025. Paul Reed, (502) 893-5748.

Louisville Astronomical Society. Museum of History and Science, 727 West Main Street, 40402. Alan Goldstein, (502) 589-4584.

Rauch Memorial Planetarium. University of Louisville, Belknap Campus, 40292. Tom Boone, (502) 588-6665. Tours, lectures, classes, planetarium shows, special children's programs. Open Monday-Sunday.

LOUISIANA

Abbeville

Astronomical Society of Acadiana. 805 South Guegnon, 70510. Dave Thomas, (318) 837-2871.

Baton Rouge

Baton Rouge Astronomical Society, Inc. 12635 Parnell Avenue, 70815. Wally Pursell, (504) 275-2395.

Louisiana Arts and Science Center Planetarium. 502 North Boulevard, 70821. Rick Greenawald, (504) 344-9465. Public observing, planetarium shows. Open Tuesday-Sunday.

Lafayette

Lafayette Natural History Museum and Planetarium. 637 Girard Park Drive, 70503. Donna Savoie, (318) 268-5544. Exhibits, classes, public observing, planetarium shows. Open Monday-Sunday. Sponsors Spaceweek activities.

Luling

St. Charles Parish Library and Planetarium. 91 Lakewood Drive, 70070. Gary Meibaum, (504) 785-8471. Tours, lectures, public observing, films, planetarium shows, open houses, special children's programs. Open Monday-Sunday.

Marrero

Pontchartrain Astronomy Society, Inc. 1441 Avenue "A", 70072. Michael Sandras, (504) 340-0256.

New Orleans

Martin Marietta/Michoud Assembly Facility. 13800 Old Gentilly Road, 70129. (504) 255-2479.

Catch a Falling Perseid **Lean back in your lawn chair around midnight on August 12, and count the Perseid meteors streaking overhead. At peak activity you could see as many as fifty meteors per hour from a dark site, and this year the Moon won't interfere with your view. Photo by Tim Pickering.**

MAINE

Easton

Francis M. Malcolm Science Center Planetarium. P.O. Box 186, U.S. Route 1-A, 04740. John T. Meader, (207) 488-5451.

Eliot

Astronomical Society of Northern New England. West Hill Observatory, 80 Goodwin Road, 03903. Ray Sutton, (207) 439-4474.

Orono

University of Maine Planetarium and Observatory. Wingate Hall, 04469. Alan W. Davenport, (207) 581-1341.

Portland

Southworth Planetarium. University of Southern Maine, 96 Falmouth Street, 04103. Roy A. Gallant, (207) 780-4249.

MARYLAND

Baltimore

Baltimore Astronomical Society. Davis Planetarium, Maryland Academy of Sciences, 601 Light Street, 21230. (301) 685-5225.

Maryland Science Center. 601 Light Street, 21230. (301) 685-5225. Exhibits, lectures, classes, films, planetarium shows, IMAX theater, special children's programs. Open Monday-Sunday.

Bel Air

Harford County Astronomical Society. P.O. Box 906, 21014. Gary McDaniel, (301) 838-1338.

Greenbelt

Goddard Astronomy Club. Goddard Space Flight Center/NASA, Code 440.8, 20771.

Hagerstown

TriState Astronomers. Washington County Planetarium, 823 Commonwealth Avenue, 21740. (301) 791-4172.

Washington County Planetarium and Space Science Center. 823 Commonwealth Avenue, 21740. Rodney L. Martin, (301) 791-4172. Exhibits, public observing, planetarium shows. By reservation only.

Silver Spring

International Occultation Timing Association. P.O. Box 7488, 20901. David W. Dunham, (301) 495-9062.

MASSACHUSETTS

Boston

Boston University Astronomy Department. 705 Commonwealth Avenue, 02215. David Bradford, (617) 353-4889. Public observing, observatory. Open Wednesday evenings.

Charles Hayden Planetarium — Boston Museum of Science. Science Park, 02114-1099. Larry Schindler, (617) 589-0270. Exhibits, space artifacts, lectures, classes, films, planetarium shows, laser shows, OMNIMAX theater, special children's programs. Open Monday-Sunday.

Cambridge

American Association of Variable Star Observers. Birch Street, 02138. Janet Mattei. (617) 354-0484.

Harvard/Smithsonian Center for Astrophysics. 60 Garden Street, 02138. Adele Walsh, (617) 495-7461. Lectures, public observing, special children's programs. Open third Thursday evenings and by reservation.

Doverry

Amateur Telescope Makers of Boston. 8 Pond Street, 02030. Gary Walker, (617) 785-0352.

Nantucket

Maria Mitchell Observatory and Loines Observatory. 3 Vestal Street, 02554. Emilia Belserene, (617) 228-9273. Public observing. Open Wednesday evenings July through mid-August. Hosts birthday commemoration of Maria Mitchell.

North Amherst

Amherst Area Amateur Astronomers Association. P.O. Box 335, 01059. Bernie Volz, (413) 253-5057.

Springfield

Springfield Science Museum. 236 State Street, 01103. Patrick Rowan, (413) 733-1194. Exhibits, lectures, classes, films, planetarium shows, special children's programs. Open Tuesday-Sunday.

Wenham

Woodside Planetarium and Observatory. 13 Friend Court, 01984. Ray Fowler, (617) 468-4815. Lectures, classes, public observing, planetarium shows. By reservation only.

West Springfield

Springfield Stars Club. 107 Lower Beverly Hills, 01089. John E. Welch, (413) 734-9179.

Williamstown

Milham Planetarium. Williams College, 01267. Jay M. Pasachoff, (413) 597-2188. Exhibits, historical astronomical instruments, public observing, planetarium shows, observatory. Open Tuesday and Thursday evenings.

Worcester

New England Science Center. 222 Harrington Way, 01604. Jean Ingraham, (617) 791-9211 extension 42.

MICHIGAN

Alpena

Jesse Besser Museum and Planetarium. 491 Johnson Street, 49707. Matt Linke, (517) 356-2202. Exhibits, tours, lectures, classes, films, planetarium shows, open houses, special children's programs. Open Monday-Sunday.

Ann Arbor

Ruthven Planetarium Theater. University of Michigan, Natural Sciences Museums, 48109-1079. Gary F. Beckstrom, (313) 764-0478. Exhibits, lectures, classes, planetarium shows, special children's programs. Open Saturday and Sunday.

Bloomfield Hills

Cranbrook Institute of Science. 500 Lone Pine Road, 48013. Jeffery Bass, (313) 645-3200. Exhibits, lectures, classes, public observing, planetarium shows, laser shows, observatory. Open Monday-Sunday.

Detroit

Children's Museum/Detroit Public Schools. 67 East Kirby, 48202. Beatrice Parsons, (313) 494-1210. Exhibits, classes, films, planetarium shows, open houses, special children's programs. Open Monday-Friday.

Detroit Astronomical Society. 14298 Lauder Avenue, 48219. (313) 981-4096.

East Lansing

Abrams Planetarium. Michigan State University, 48824. David Batch, (517) 355-4676. Exhibits, public observing, planetarium shows, special children's programs. Open Monday-Sunday.

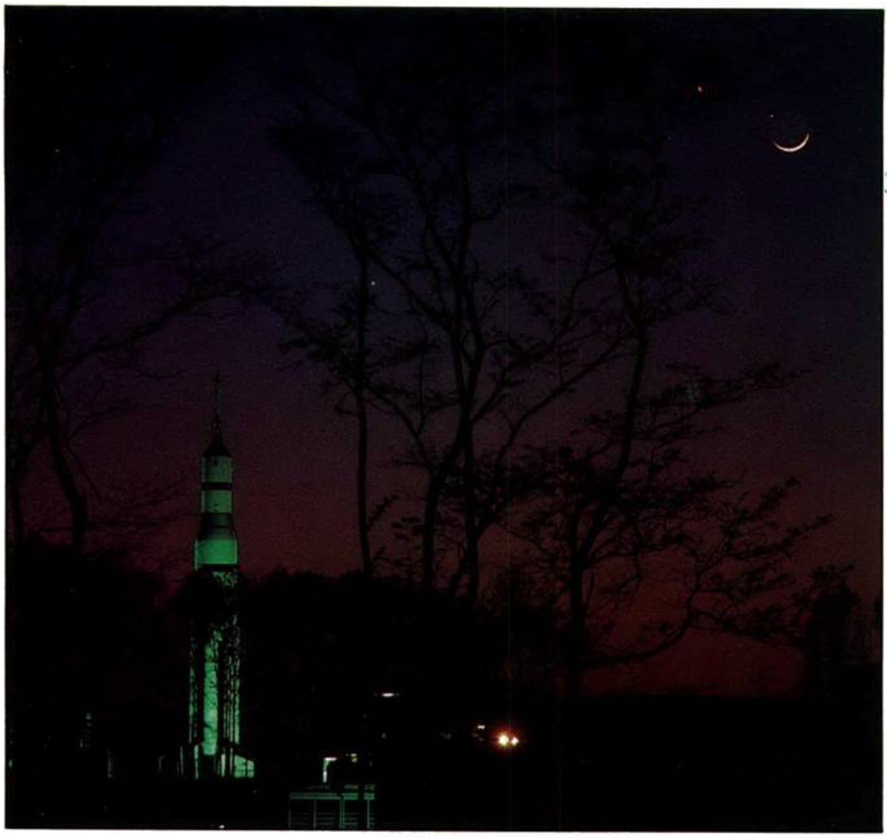
Capital Area Astronomy Club. Abrams Planetarium, Michigan State University, 48824. David Batch, (517) 355-4676.

Flint

Robert T. Longway Planetarium. 1310 East Kearsley Street, 48503. Michael Gardner, (313) 762-1181. Exhibits, space artifacts, planetarium shows. By reservation only.

Grand Rapids

Roger B. Chaffee Planetarium. Grand Rapids Public Museum, 233 Washington SE, 49503. David L. DeBruyn, (616) 456-3985. Exhibits, space artifacts,



Explore the History of Space See space shuttle, *Spacelab*, and *Skylab* displays plus the historic test site of the Mercury-Redstone rocket, which carried astronauts Alan Shepard and Gus Grissom into space, at Marshall Space Flight Center in Huntsville, Alabama. In the photo is a Saturn 1 rocket. Photo by Mark Jones.

classes, planetarium shows, laser shows, special children's programs. Open Monday-Sunday.

Kalamazoo

Hans Baldauf Planetarium. Kalamazoo Public Museum, 315 South Rose Street, 49007. Eric Schreur, (616) 345-7092. Exhibits, planetarium shows, special children's programs. Open Tuesday-Saturday.

Lowell

Grand Rapids Amateur Astronomical Association. James C. Veen Observatory, 3308 Kissing Rock Road SE, 49331. Evelyn Marron, (616) 897-7065.

Marquette

Marquette Astronomical Society. Shiras Planetarium, 1203 West Fair Avenue, 49885. John R. Shibley, (806) 225-1066. Sponsors the 1988 North Central Astronomical League Regional Convention.

Shiras Planetarium. Marquette Senior High School, 1203 West Fair Avenue, 49855. D. Scott Stobbelaar, (906) 225-4204.

Mount Pleasant

Brooks Observatory. Central Michigan University, 48859. Wayne Osborn, (517) 774-3375. Public observing, observatory. By reservation only.

Muskegon

Muskegon Astronomical Society. P.O. Box 363, 49443. Dale Johnson, (616) 798-7680.

MINNESOTA

Duluth

Alworth Planetarium. University of Minnesota-Duluth, 55812. Glenn Langhorst, (218) 726-7129. Exhibits, historical astronomical instruments, lectures, planetarium shows, special children's programs. Open Wednesday.

Arrowhead Astronomical Society. Alworth Planetarium, University of Minnesota-Duluth, 55812. Glenn Langhorst, (218) 726-7129.

Hibbing

Paulucci Space Theater. Arrowhead Community College Region, 55746. Peter Davis, (218) 262-6720. Exhibits, tours, films, planetarium shows. Open Monday-Sunday.

Minneapolis

Minneapolis Planetarium. 300 Nicollet Mall, 55401. Rodney M. Nerdahl, (612) 372-6644. Exhibits, planetarium shows, special children's programs. Open Monday-Sunday June 13-September 4.

Moorhead

Moorhead-Fargo Astronomical Society. Department of Physics, Concordia College, 56560.

Moorhead State University Planetarium. 8th Avenue and 11th Street S, 56560. David Weinrich, (218) 236-3982. Public observing, planetarium shows, special children's programs. Open Thursday and by reservation.

New Ulm

Dr. Martin Luther College. College Heights, 56073. J. Paulsen, (507) 354-8221 extension 249. Public observing, planetarium shows. By reservation only.

Minnesota Valley Amateur Astronomers. Route 4, Box 15A, 56073. Roger Dier, (507) 359-2488. Sponsors the 1988 Minnesota Valley Amateur Astronomers Southern Minnesota Sky Show.

St. Cloud

St. Cloud State University Observatory and Planetarium. 56301. David Targan, (612) 255-2013. Classes, public observing, planetarium shows, special children's programs. By reservation only.

St. Paul

Minnesota Astronomical Society. 30 East 10th Street, 55101. Max Radloff, (612) 451-7680.

MISSISSIPPI

Jackson

Jackson Astronomical Association. 6207 Winthrop Circle, 39206. Walter Rebmann, Jr., (601) 982-2317.

Ronald E. McNair Space Theater/Russell Davis Planetarium. 201 East Pascagoula Street, 39201. Mary Herron, (601) 960-1550. Exhibits, historical astronomical instruments, space artifacts, public observing, films, planetarium shows, laser shows. Open Tuesday-Sunday.

MISSOURI

Blue Springs

Astronomical Society of Kansas City. P.O. Box 400, 64015. (816) 432-9077.

Kansas City

Kansas City Museum Planetarium. 3218 Gladstone Boulevard, 64123. Susan Peterson, (816) 483-8300. Exhibits, space artifacts, lectures, public observing, planetarium shows, special children's programs. Open Tuesday-Sunday.

St. Louis

St. Louis Astronomical Society. 14055 Baywood Villages, 63017. Cecelia Brown, (314) 278-1191.

St. Louis Science Center. 5100 Clayton Avenue, 63110. John Wharton, (314) 289-4444. Exhibits, space artifacts, lectures, public observing, planetarium shows, special children's programs. Open Monday-Sunday.

Winfield

Rural Astronomers of Missouri. Route 1, Box 501, 63389. John Sgouros, (314) 668-8574.

NEBRASKA

Lincoln

Mueller Planetarium. 210 Morrill Hall, 14th and U Streets, 68588-0338. Jack Dunn, (402) 472-2641. Exhibits, space artifacts, films, planetarium shows, laser shows. Open Tuesday-Sunday.

Prairie Astronomy Club. P.O. Box 80553, 68501. Delmar Motycka, (402) 489-2520.

Omaha

Omaha Astronomical Society. 3390 South 130th Street, 68144. George Allen, (402) 333-1097. Hosts ALCON '88.

NEVADA

Elko

Elko Nevada Astronomical Society. 550 South 12th #22, 89801. Len Seymour, (702) 738-7916.

Las Vegas

Clark County Community College. 3200 East Cheyenne Avenue, 89030. Dale Etheridge, (702) 644-5059. Films, planetarium shows, special children's programs. Open Thursday-Saturday.

Las Vegas Astronomical Society. Clark County Community College, 3200 East Cheyenne Avenue, 89030. John Ruff, (702) 459-8401.

Reno

Astronomical Society of Nevada. 825 Wilkinson Avenue, 89502. Italo Gavazzi, (702) 329-9946.

Fleischmann Planetarium. University of Nevada-Reno, 89557. (702) 784-4812. Exhibits, public observing, films, planetarium shows. Open Monday-Sunday.

NEW HAMPSHIRE

Hanover

Dartmouth College. 03755. Thomas Kenyon, (603) 646-2034.

Keene

Keene Amateur Astronomers, Inc. 12 Gardner Street, 03431. Philip N. Atwood, (603) 352-5058.

NEW JERSEY

Boonton

Sheep Hill Astronomical Association. P.O. Box 111, Ross Drive, 07005. Evert Bono, (201) 335-5990.

Clifton

North Jersey Astronomical Group. Rifle Camp Park Nature Center, P.O. Box 4021, Allwood Station, 07012. (201) 523-0024.

Cranford

Amateur Astronomers, Inc. Union College, Sperry Observatory, 07016. Roger W. Tuthill, (201) 232-1786.

High Bridge

New Jersey Astronomical Association. Vorhees State Park, P.O. Box 214, 08829. Ben Cavotta, (215) 253-7294.

Lincroft

STAR Astronomy Society. Monmouth County Park System, Newman Springs Road, 07738. Doug Krampert, (201) 872-2670.

Mountainside

Trailside Planetarium. Trailside Nature and Science Center, Coles Avenue and New Providence Road, 07092. Lonny Buinis, (201) 232-5930. Exhibits, tours, lectures, classes, films, planetarium shows, special children's programs. Open Monday-Sunday.

Newark

Newark Museum Planetarium. 43-53 Washington Street, 07101. Jerome Vinski, (212) 596-6609. Public observing, planetarium shows, special children's programs. Open Tuesday-Sunday.

Princeton

Amateur Astronomers Association of Princeton. P.O. Box 2017, 08540.

Toms River

ASTRA. Novins Planetarium, Ocean County College, 08754-2001.

Robert J. Novins Planetarium. Ocean County College, 08754-2001. R. Erik Zimmermann. Classes, planetarium shows, special children's programs. Open Monday-Friday.

NEW MEXICO

Alamogordo

Alamogordo Amateur Astronomers. 1210 Filipino, 88310. Paula Hamilton, (505) 434-0115.

The Space Center. Top of New Mexico Highway 2001, Box 533, 88310. Arthur G. Barton, (505) 437-2840. Exhibits, space artifacts, tours, lectures, classes, films, planetarium shows, laser shows, OMNIMAX theater, special children's programs. Open Monday-Sunday.

Albuquerque

Albuquerque Astronomical Society. 14328 Mocho NE, 87123. Bruce L. Levin, (505) 299-0891.

University of New Mexico. 87131. Exhibits, public observing. Open Monday-Friday.

Socorro

National Radio Astronomy Observatory. P.O. Box 0, 87801-0387. Ron Ekers, (505) 772-4011. Exhibits, films. Open Monday-Sunday.

NEW YORK

Alfred

Alfred University. 14802. John Stull, (607) 871-2208. Public observing, observatory, open houses. Open Thursday evenings June-July.

Bay Shore

Astronomical Society of Long Island, Inc. 1011 Howells Road, 11706. Jo-Ann Tompkins, (516) 586-1760.

Binghamton

Roberson Planetarium. 30 Front Street, 13905. William L. Buckingham, (607) 772-0660. Exhibits, tours, lectures, classes, public observing, films, planetarium shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Buffalo

Buffalo Astronomical Association, Inc. Buffalo Museum of Science, Humboldt Parkway, 14211. Doris Koestler, (716) 683-2970.

Ferguson Planetarium. State University College at Buffalo, 1300 Elmwood Avenue, 14222. Arthur Gielow, (716) 878-4911. Planetarium shows.

Centerport

Vanderbilt Planetarium. 178 Little Neck Road, 11721. Mark Levine, (516) 757-7500. Exhibits, tours, lectures, classes, public observing, planetarium shows, observatory, special children's programs. Open Tuesday-Sunday.

Fredonia

Planetarium. SUNY College at Fredonia, 14063. Daniel C. Dobey, (716) 673-3370.

Herkimer

Herkimer County BOCES. 400 Gros Boulevard, 13350. Theodore Stalec, (315) 867-2088. Lectures, classes, planetarium shows. By reservation only.

Ithaca

Cornell University. 14853-6801. Yervant Terzian, (607) 255-4206. Classes, public observing, observatory. Open Friday evenings.

Spacecraft Planetary Imaging Facility. Cornell University, 317 Space Sciences Building, 14850. Margaret Dermott, (607) 255-3833.

Lindenhurst

Amateur Observers Society of New York. 707 South 9th Street, 11757. Eric Barnes, (516) 957-3713.

Middle Island

Longwood District Planetarium. Middle Island-Yaphank Road, 11953. Joseph E. Caprioglio, (516) 345-2741. Lectures, classes, public observing, planetarium shows. Open Wednesday evenings and by reservation.

New York

exchange or swap shop or listing of used telescopes

Amateur Astronomers Association of New York, Inc. 1010 Park Avenue, 10028. Sidney Scheuer, (212) 535-2922.

American Museum/Hayden Planetarium. Central Park West at 81st Street, 10024-5192. William Gutsch, (212) 769-5900. Exhibits, historical astronomical instruments, space artifacts, classes, planetarium shows, laser shows, special children's programs. Open Monday-Sunday.

Pearl River

Rockland Astronomy Club. 110 Pascack Avenue, 10965. Allan Green, (914) 735-7303.

Potsdam

Potsdam College of Arts and Science. State University of New York, 13676. A. R. McRobbie, (315) 267-2286. Tours, lectures, classes, planetarium shows, open houses. By reservation only.

Rochester

Strasenburgh Planetarium. Rochester Museum and Science Center, 657 East Avenue, 14607. Donald S. Hall, (716) 271-4320. Exhibits, classes, public observing, planetarium shows, laser shows, observatory, special children's programs. Open Monday-Sunday.

Saranac Lake

Tri-Lakes Astronomical Society. P.O. Box 806, 12983. Dan Ferguson, (518) 891-0339.

Schenectady

Albany Area Amateur Astronomers. 1529 Valencia Road, 12309. Bob Mulford, (518) 374-8744.

Schenectady Museum and Planetarium. Nott Terrace Heights, 12308. Richard Monda, (518) 346-3862. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, public observing, films, planetarium shows, laser shows, observatory, special children's programs. Open Tuesday-Sunday.

Syracuse

Discovery Center of Science and Technology. 321 South Clinton Street, 13202. Stephen Karon, (315) 425-9068. Exhibits, lectures, classes, public observing, films, planetarium shows, special children's programs. Open Tuesday-Sunday. Sponsors the Great Snowball Melt solstice celebration.

Syracuse Astronomical Society, Inc. 1115 East Colvin Street, 12310. Denise Sabatini, (315) 458-1454.

Troy

Rensselaer County Junior Museum. 282 5th Avenue, 12182. Margo Bloom, (518) 235-2120. Exhibits, tours, classes, planetarium shows, special children's programs. Open Monday-Wednesday, Saturday, and Sunday.

Vestal

Broome County Astronomical Society. Roberson-Kopernik Observatory, Underwood Road, 13850. Jay Sarton, (607) 748-3685. Sponsors Astrofest '88.

Yonkers

Andrus Planetarium. 511 Warburton Avenue, 10701. Jon Elvert, (914) 963-4550. Exhibits, lectures, classes, public observing, films, planetarium shows, observatory, special children's programs. Open Wednesday-Sunday.

NORTH CAROLINA

Castle Hayne

Cape Fear Astronomy Club. 110 Linville Drive, 28429. Paul H. Petty, (919) 675-2952.

Chapel Hill

Morehead Planetarium. University of North Carolina, East Franklin Street, 27514. (919) 962-1248.

Charlotte

Discovery Place and Nature Museum. 301 North Tryon Street, 28202. Mike Blanton, (704) 372-6261 Exhibits, historical astronomical instruments, tours, lectures, classes, films, planetarium shows, laser shows, open houses, special children's programs. Open Monday-Sunday.

Fayetteville

Astronomy Club of Cumberland County. 2308 Colgate Drive, 28304. Allen Faircloth, (919) 485-8515.

Granite Falls

Catawba Valley Astronomy Club. 12 East Street, 28630. Greg Kirby, (704) 396-7656.

Greensboro

Edward Zane Planetarium. The Natural Science Center of Greensboro, 4301 Lawndale Drive, 27408. Roger D. Joyner, (919) 288-3769. Exhibits, historical astronomical instruments, space artifacts, planetarium shows, observatory. Open Monday-Sunday.

Three College Observatory. Department of Physics and Astronomy, University of North Carolina-Greensboro, 27412. Stephen Danford.

Hickory

Catawba Science Center. 243 3rd Avenue NE, P.O. Box 2431, 28603. Trish Little, (704) 322-8169. Exhibits, tours, classes, films, planetarium shows, special children's programs. Open Tuesday-Sunday.

Salisbury

Astronomical Society of Rowan County. Margaret Woodson Planetarium, 1636 Parkview Circle, 28144. Ellen Trexler, (704) 636-3462.

Margaret C. Woodson Planetarium. 1636 Parkview Circle, 28144. Ellen Trexler, (704) 636-3462. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, public observing, films, planetarium shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Shelby

Cleveland County Astronomy Society. 825 Ivywood Drive, 28150.

Trinity

Thomasville Area Astronomy Club. Route 3, Box 273, 27370. Arthur Oates, (919) 431-5062.

Winston-Salem

Forsyth Astronomical Society. 504 Gayron Drive, 27105. Stan Griffin, (919) 744-7141.

Nature Science Center. Museum Drive, 27105. Pat Fromen, (919) 767-6730. Exhibits, classes, public observing, planetarium shows, special children's programs. Open Monday-Sunday.

NORTH DAKOTA

Bismarck

Dakota Astronomical Society. P.O. Box 2539, 58502-2539. John R. Wetsch, (701) 222-0673.

Grand Forks

University of North Dakota Atmospherium. Center for Aerospace Sciences, P.O. Box 8216, University Station, 58202. Leon F. Osborne, (701) 777-2184. Exhibits, space artifacts, tours, films, planetarium shows. Open Thursday-Sunday.

Minot

Minot State University. 500 University Avenue West, 58701. DeWayne Martin, (701) 857-3071. Public observing, observatory.

OHIO

Akron

Astronomy Club of Akron, Inc. 131 Oakdale Avenue, 44302. Lauri Kunkel, (216) 762-5748. Sponsors the 1988 Ohio Turnpike Astronomers Association Convention.

Bay Village

Schuele Planetarium. 28728 Wolf Road, 44140. Bill Kobel, (216) 835-9912. Planetarium shows. Open Sunday.

Canton

Hoover-Price Planetarium. McKinley Museum, 800 McKinley Monument Drive, 44708. Jane W. Mahoney, (216) 455-7043. Exhibits, space artifacts, tours, lectures, classes, planetarium shows, special children's programs. Open Monday-Sunday.

Chagrin Falls

Chagrin Valley Astronomical Society. P.O. Box 11, 44022. Don Himes, (216) 247-5114. Sponsors the Chagrin Valley Astronomical Society Convention.

Cincinnati

Cincinnati Museum of Natural History and Planetarium. 1720 Gilbert Avenue, 45202. Roberta M. Burnes, (513) 621-3889. Exhibits, lectures, classes, planetarium shows, special children's programs. Open Tuesday-Sunday, Monday until June 6.

University of Cincinnati Observatory. Physics Department, 45221-0011. Paul Nohr, (513) 321-5186.

Cleveland

Cleveland Museum of Natural History/Mueller Planetarium. Wade Oval, University Circle, 44106. Joseph DeRocher, (216) 231-4600. Exhibits, public observing, planetarium shows, observatory, special children's programs. Open Monday-Sunday.

Visitor Center at NASA's Lewis Research Center. 21000 Brookpark Road, 44135. Doris Forror, (216) 433-2004. Exhibits, space artifacts, tours, lectures, classes, special children's programs. Open Monday-Sunday.

Columbus

Columbus Astronomical Society. P.O. Box 16209, 43216. Tom Burns, (614) 262-9713.

Dayton

Dayton Museum of Natural History. 2629 Ridge Avenue, 45414. Arthur F. Goss, (513) 275-7432. Exhibits, historical astronomical instruments, lectures, classes, public observing, films, planetarium shows, observatory, special children's programs. Open Monday-Sunday.

Miami Valley Astronomical Society. 2629 Ridge Avenue, 45414. Wade E. Allen, (513) 275-7431. Sponsors the Seventeenth Annual Apollo Rendezvous and Telescope Fair.

Granville

Swasey Observatory. Denison University, 43023. Sandra Yorka, (614) 587-6477. Tours, public observing, open houses. Open Monday-Friday.

Lorain

Black River Astronomical Society. 1631 Maple Drive, 44052. Michael Harkey, (216) 288-8556.

Parma

Cuyahoga Astronomical Association. P.O. Box 29089, 44129. Dawn Jenkins, (216) 521-5115.

Sylvania

Copernicus Planetarium. Lourdes College, 43560. Anthony Pisano, (419) 885-3211. Exhibits, tours, lectures, planetarium shows, special children's programs. Open Monday-Saturday.

Westerville

North American Astrophysical Observatory. Otterbein College, 43081. Phillip Barnhart, (614) 882-3601.

Youngstown

Youngstown State University Planetarium. 44555. Warren Young, (216) 742-3616.

OKLAHOMA

Boise City

Cimmarron County Star Gazers. P.O. Box 278, 73933. Jim Rosebery, (405) 544-2222.

Fort Sill

Fort Sill Planetarium. Target Acquisition Department, Survey Division, 73503. London Hill, (405) 351-6616. Planetarium shows. Open Monday-Friday by reservation only.

Oklahoma City

Oklahoma City Astronomy Club. 2100 NE 52, 73111. Wayne Wyrick, (405) 424-5545.

Pocola

Arkansas-Oklahoma Astronomical Society. Route 3, Box 421W, 74902. Larry Kennedy, (918) 436-2204. Sponsors the 1988 Arkansas Star Party.

OREGON

Bend

University of Oregon Pine Mountain Observatory. Bend-Burns Star Route, 97702. James C. Kemp, (503) 382-8331. Tours, lectures, public observing. Open Friday-Sunday evenings and by reservation.

Portland

OMSI Astronomers. 4015 SW Canyon Road, 97221. John Buting, (503) 228-OMSI. Sponsors the 1988 Summer Star Party.

Oregon Museum of Science and Technology/Harry C. Kendall Planetarium. 4015 SW Canyon Road, 97221. Jan Paul Dabrowski, (503) 222-2828. Exhibits, space artifacts, lectures, classes, public observing, planetarium shows, laser shows, open houses, special children's programs. Open Monday-Sunday.

Portland Astronomical Society. 2626 SW Luradel, 97219. Don Botteron, (503) 245-6251.

Veronia

Northwest Astronomy Group. 55371 McDonald Road, 97064. Sandy Mikalow.

PENNSYLVANIA

Allentown

Lehigh Valley Amateur Astronomical Society, Inc. 620 East Rock Road, 18103. Robert Mohr, (215) 797-3476.

Erie

Erie Historical Museum Planetarium. 356 West 6th Street, 16507. Eugene A. Jenneman, (814) 453-5811. Exhibits, classes, planetarium shows, special children's programs. Open Tuesday-Sunday.

Harrisburg

State Museum of Pennsylvania Planetarium. 3rd and North Street, 17108. Jeffrey L. Smith, (717) 783-9914.

Kane

Sir Isaac Newton Astronomical Society. Box 591, 16735. William Bloom, (814) 837-6137.

Lancaster

North Museum Planetarium. Franklin and Marshall College, College and Buchanan Avenues, 17603. Jordan Marche, (717) 291-3941. Exhibits, public observing, planetarium shows, observatory. Open Wednesday-Sunday.

Lansdale

L5 Society of Philadelphia. 1825 Flintlock Circle, 19446. Jay B. Haines, (215) 855-7130. Sponsors Spaceweek activities.

Lewisberry

Astronomical Society of Harrisburg. P.O. Box 356, 17339. (717) 938-6041.

Bucknell University. 17837. Anthony J. Nicastro, (717) 524-1139. Exhibits, historical astronomical instruments, tours, lectures, classes, public observing, observatory, open houses. Open by reservation only.

Lock Haven

Lock Haven University/Ulmer Planetarium. 17745. Donald L. Brobst, (717) 893-2075. Classes, planetarium shows, special children's programs. Open Monday-Friday and by reservation.

New Kensington

Kiski Astronomers. 2 Aluminum City Terrace, 15068. Dennis Sopchack, (412) 337-0509.

Philadelphia

Delaware Valley Amateur Astronomers. 6233 Cator Avenue, 19149. Bob Summerfield, (215) 831-0485.

Franklin Institute/Fels Planetarium. 20th and the Parkway, 19103. Derrick Pitts, (215) 448-1293. Exhibits, space artifacts, lectures, classes, public observing, planetarium shows, observatory, special children's programs. Open Monday-Sunday.

Rittenhouse Astronomical Society. P.O. Box 12531, 19131. Milt Friedman, (215) 886-3466.

Pittsburgh

Allegheny Observatory. 159 Riverview Avenue, 15214. Nancy Robinson, (412) 321-2400.

Buhl Science Center. Allegheny Square, 15212. Mary Pat McCarthy, (412) 321-4302. Exhibits, tours, lectures, classes, public observing, films, planetarium shows, laser shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Reading

Berks County Amateur Astronomical Society. Reading School District Planetarium, 1211 Parkside Drive South, 19611.

Reading School District Planetarium. 1211 Parkside Drive South, 19611-1441. Fred Hessler, (215) 371-5854. Exhibits, classes, planetarium shows, special children's programs. Open Monday-Friday.

Scranton

Everhart Museum Planetarium. Nay Aug Park, 18510. William Speare, (717) 346-8370. Exhibits, tours, lectures, planetarium shows. Open Tuesday-Sunday.

Villanova

Planetarium and Observatory. Villanova University, Department of Astronomy and Astrophysics, 19085. (215) 645-4820.

RHODE ISLAND

Cumberland

Aurora Alert Hotline. 57 Manville Hill Road #10, 02864. David A. Huestis, (401) 765-5778.

North Scituate

Skyscrapers, Inc. 47 Peep Toad Road, 02857. Bob Napier, (401) 934-0980.

Providence

Cormack Planetarium. Museum, Roger Williams Park, 02905. Francine Jackson, (401) 785-9450.

Ladd Observatory. 210 Doyle Avenue, 02912. Hendrik J. Gerristen, (401) 863-1488.

SOUTH CAROLINA

Columbia

Gibbes Planetarium. 1112 Bull Street, 29201. Richard McColman, (803) 799-2810. Planetarium shows. Wednesday evening, Saturday, and Sunday.

Midland Astronomy Club. 636 Lewisham Road, 29210. (803) 799-8703.

Florence

Francis Marion College Planetarium and Observatory. 29501. Ed Dooley, (803) 661-1250. Public observing, planetarium shows. Open Sunday.

Greenville

Roper Mountain Science Center. 504 Roper Mountain Road, 29615. Doug Green, (803) 297-0232. Historical astronomical instruments, public observing, observatory. Open Friday evenings by reservation.

Orangeburg

Stanback Museum and Planetarium. South Carolina State College, 29117. (803) 536-8711. Exhibits, public observing, special children's programs. Open Monday-Friday.

Rock Hill

Settlemyre Planetarium/Museum of York County/Carolina Skygazers Astronomy Club. 4621 Mount Gallant Road, 29730. M. Leon Knott, (803) 329-2121. Exhibits, lectures, classes, public observing, planetarium shows, special children's programs. Open Tuesday-Sunday. Sponsors the 1988 Amateur Astronomers/Astrophotographers Convention and Heavens Above! astrophotography exhibit.

TENNESSEE

Brentwood

A. J. Dyer Observatory. Vanderbilt University, 1000 Oman Drive, 37027. Douglas S. Hall, (615) 373-4897. Exhibits, historical astronomical instruments, lectures, public observing, films, open houses. Open evenings only.

Chattanooga

Barnard Astronomical Society. P.O. Box 90042, 37412. Frank R. Helms, (615) 622-4762.

Kingsport

Bays Mountain Amateur Astronomers. Route 4, 37660. (615) 229-9447.

Bays Mountain Planetarium and Nature Center. Route 4, 37660. (615) 229-9447. Exhibits, planetarium shows, laser shows. Open Monday-Sunday.

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Knoxville

Meteorical Society. Department of Geological Sciences, University of Tennessee, 37996.

Orion Research Forum and Network. P.O. Box 50291, 37950. Bob Miles, (615) 482-3829. Sponsors Spaceweek activities.

Smoky Mountain Astronomical Society. P.O. Box 6204, 37914-0204. Rita Fairman, (615) 637-1121.

Manchester

Middle Tennessee Astronomy Society. 1305 Sycamore Street, 37355. Donald W. Male, (615) 728-7321.

Memphis

Memphis Pink Palace Museum and Planetarium. 3050 Central Avenue, 38111. George Brown, (901) 454-5609.

Memphis Astronomical Society. P.O. Box 11301. Richard Moore, (901) 682-2003.

Murfreesboro

Middle Tennessee State University. 37132. Roy W. Clark, (615) 898-2956. Classes, public observing, observatory. Open evenings only.

Nashville

Sudekum Planetarium/Cumberland Science Museum. 800 Ridley Boulevard, 37211. Kris McCall, (615) 259-6383. Exhibits, classes, planetarium shows, special children's programs. Open Monday-Sunday.

Tullahoma

Middle Tennessee Astronomical Society. 113 Crestwood, 37388. Martin Nelius, (615) 455-5132.

TEXAS

Abilene

Abilene Astronomical Society, Inc. 1109 Highland Avenue, 79605. George Schroeder, (915) 677-5713.

Amarillo

Amarillo Astronomy Club. 5303 South Milam, 79110. Robert Loper, (806) 355-6295.

Don Harrington Discovery Center. 1200 Streit Drive, 79106. Robert Bauman, Jr., (806) 355-9547. Exhibits, classes, public observing, films, planetarium shows, open houses, special children's programs. Open Tuesday-Sunday.

Arlington

Fort Worth Astronomical Society. 1519 San Francisco Court #202, 76012. Kaye Hutchins, (817) 860-6858.

College Station

Association of Amateur Astronomers. Texas A&M University, Department of Physics, 77843-4242. Roger Smith, (409) 845-4179.

Corpus Christi

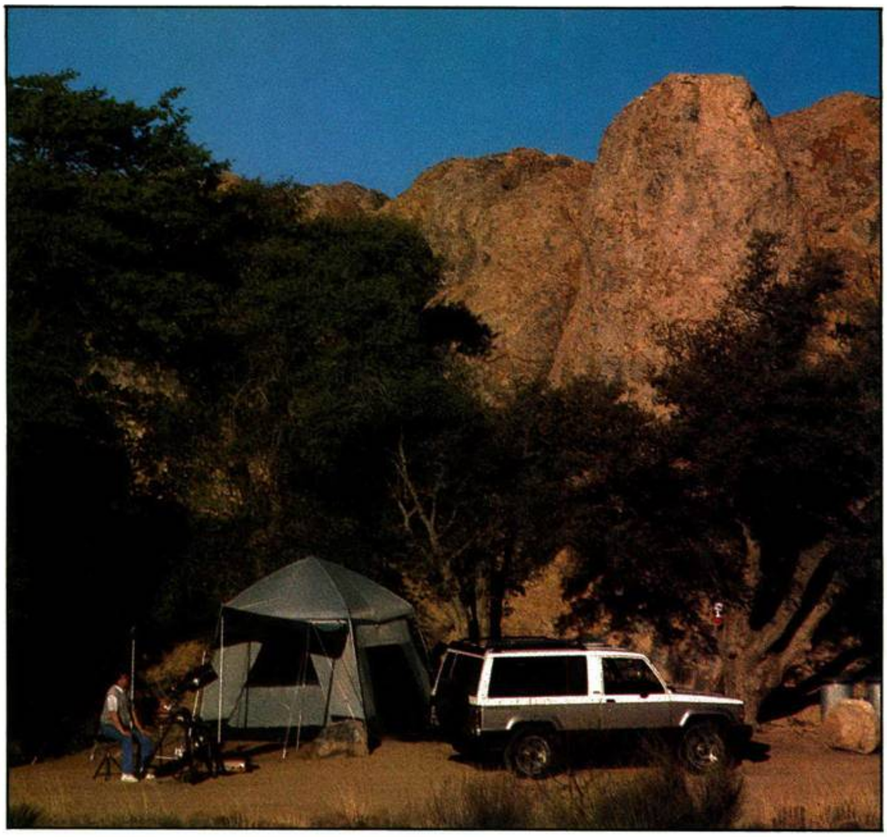
Corpus Christi Astronomical Society. 3814 Marion Street, 78415. Gary Mayer, (512) 852-7643.

Richard King High School Planetarium. 5225 Gollihar Road, 78412. Robert Wollman, (512) 992-0942. Exhibits, planetarium shows. Open Tuesday evenings until June 14.

Dallas

Science Place Planetarium. 1620 First Avenue, 75210. (214) 428-7200.

Texas Astronomical Society. P.O. Box 25162, Preston Station, 75225. Sharon Cherry, (214) 358-3097.



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El Paso

El Paso Independent School District Planetarium. 6531 Boeing Drive, 79998. John R. Peterson, (915) 779-4317.

Fort Davis

McDonald Observatory/W. L. Moody Visitor's Center. P.O. Box 1337, 79734. Robert Scheppler, (915) 426-3263. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, public observing, films. Open Monday-Sunday.

Texas Star Party. Prude Ranch. Contact the TSP Registrar, Department "A", 6433 Cedar Hollow, Dallas, TX 75248.

Fort Worth

Fort Worth Astronomical Society. P.O. Box 161715, 76161-1715. Monty Truitt, (817) 496-9777.

Texas Observers. Fort Worth Museum of Science and History, 1501 Montgomery Street, 76107.

Houston

Houston Astronomical Society. 8522 Bluegate Drive, 77025. (713) 661-6180.

Lyndon B. Johnson Space Center/Olin Teague Visitor Center. 2101 NASA Road 1, Public Services Branch, AP4, 77058. Charles A. Biggs, (713) 483-4241. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, public observing, films, special children's programs. Open Monday-Sunday.

Lubbock

Moody Planetarium. 4th and Indiana, P.O. Box 4499, 79409. Ron Twellman, (806) 742-2441. Exhibits, space artifacts, planetarium shows. Open Tuesday-Sunday.

South Plains Astronomy Club. 1920 46th Street, 79412-2214. Wayne Lewis, (806) 763-6800.

Odessa

Odessa Meteor Crater. P.O. Box 3626, 79760. Exhibits. Open Monday-Sunday.

San Angelo

Angelo State University Planetarium. 76909. Mark S. Sonntag, (915) 942-2136. Exhibits, classes, public observing, planetarium shows. Open Monday-Saturday.

San Antonio

San Antonio College Planetarium. 1300 San Pedro Avenue, 78284. Bryan A. Snow, (512) 733-2910. Exhibits, lectures, public observing, planetarium shows, observatory, special children's programs. Open Sunday evenings and by reservation.

Sanger

Denton County Astronomical Society. 225 Green Springs Circle, 76266. John Love, (817) 458-7479.

Texas City

Astronomy Club. College of the Mainland, Division of Mathematics, Health, and Natural Science, 77591. John Hubisz, (409) 938-1211 extension 325.

Tyler

Hudnall Planetarium. Tyler Junior College, P.O. Box 9020, 75711. Bill Walker, (214) 531-2312. Exhibits, classes, public observing, planetarium shows. Open Tuesday-Friday and Sunday.

UTAH

Cedar City

Southern Utah Astronomy Group. 147 South 300 East, 84720. Brent Sorensen, (801) 586-2759.

Ogden

Ogden Astronomical Society. 2336 West 5650 South, 84067. Bob Tillotson, (801) 773-8106.

Salt Lake City

Hansen Planetarium. 15 South State Street, 84111. Von Del Chamberlain, (801) 538-2104. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, planetarium shows, laser shows, IMAX theater, special children's programs. Open Monday-Sunday.

Salt Lake City Astronomical Society. 15 South State Street, 84111. David Bernson, (801) 467-2126.

VERMONT

Essex Junction

Vermont Astronomical Society. 115 Sherwood Square, 05452. Russell Chmela, (802) 878-3459.

St. Johnsbury

Fairbanks Museum and Planetarium. Main Street, 05819. Mark Breen, (802) 748-2372.

Springfield

Stellafane. Contact: Dennis di Cicco, 60 Victoria Road, Sudbury, MA 01776.

Williston

Vermont Astronomical Society. P.O. Box 782, 05495. Brad P. Vietje, (802) 425-2638.

VIRGINIA

Ashland

Keeble Observatory. Randolph Macon College, 23005. George F. Spagna, Jr., (804) 798-8372. Public observing, open houses. Open evenings by reservation only.

Charlottesville

Leander McCormick Observatory. University of Virginia, Department of Astronomy, P.O. Box 3818, 22903. Summer Chairman, (804) 924-7494. Open first and third Fridays.

Chesapeake

Back Bay Amateur Astronomers. 2808 Flag Road, 23323. Glendon L. Howell, (804) 485-4242. Sponsors the Fourteenth Annual Virginia Association of Astronomical Societies Convention.

Fort Union

Wicker Planetarium. Fort Union Military Academy, P.O. Box 278, Route 15, 23055. Billy Ozment, (804) 842-3082.

Hampton

NASA Langley Visitor Center. Mail Stop 480, 23665. Ray Goodman, (804) 865-2855. Exhibits, space artifacts, tours, lectures, films. Open Monday-Sunday.

Harrisonburg

John C. Wells Planetarium. James Madison University, 22801. John Wells, (703) 568-6109. Planetarium shows. Open Monday and Thursday evenings.

Shenandoah Valley Astronomy Club. James Madison University, Department of Physics, 22807. Henry W. Leap, (703) 568-6109.

Newport News

Planetarium of the Virginia Living Museum. 524 J. Clyde Morris Boulevard, 23601. Jon U. Bell, (804) 595-1900. Exhibits, lectures, classes, public observing, planetarium shows, observatory, open houses, special children's programs. Open Monday-Sunday.

Reston

Reston L5 Society. 11208 Chestnut Grove Square #5, 22090-5105. Gary Sanger, (703) 435-0019.

Richmond

Science Museum of Virginia/Universe Space Theater. 2500 West Broad Street, 23220. Margaret D. Austin, (804) 257-1657.

Springfield

Northern Virginia Astronomy Club. 5608 Flag Run Drive, 22151. John Scott Huggins, (703) 644-4331.

Virginia Beach

Virginia Beach Planetarium. Plaza Junior High School, 3080 South Lynnhaven Road, 23451. Herb Teuscher, (804) 431-4067. Exhibits, lectures, classes, planetarium shows, open houses. Open Monday-Friday, Sunday evenings, closed July.

Wallops Island

Wallops Flight Facility's NASA Visitor Center. 23337. Keith A. Koehler, (804) 824-2298. Exhibits, space artifacts, films. Open Monday, Thursday-Sunday.

WASHINGTON

Bellevue

Bellevue Community College. 3000 Landerholm Circle, 98007. Jim Rostirolla, (206) 641-2321. Lectures, classes, public observing, planetarium shows, special children's programs. Open Monday-Friday by reservation.

Centralia

Southwest Washington Astronomical Society. 2421 Leisure Lane, 98531. Carl M. Newton, (206) 736-6144.

Cheney

Eastern Washington Science Center. Riverfront Park, 99004. Eileen M. Starr, (509) 359-6391. Exhibits, lectures, classes, planetarium shows. Open Monday-Sunday.

Goldendale

Goldendale Observatory. Goldendale Observatory State Park, 1602 Observatory Drive, 98620. Stephen R. Stout, (509) 773-3141. Exhibits, tours, lectures, public observing, films. Open Wednesday-Sunday.

Mead

Spokane Astronomical Society. P.O. Box 404, 99021. Thom Jenkins, (509) 535-0499.

Richland

Tri-City Astronomy Club. 1907 Luther Place, 99352. Betty Hanlon, (509) 943-5304.

Seattle

Pacific Science Center. 200 Second Avenue North, 98109. Charles Hafey, (206) 433-2920. Exhibits, classes, planetarium shows, laser shows, IMAX theater, special children's programs. Open Monday-Sunday.

WEST VIRGINIA

Davis

Blackwater Falls State Park. P.O. Box 490, 26260. Pat Northeimer, (304) 259-5216.

Green Bank

National Radio Astronomy Observatory. P.O. Box 2, 24944-0002. George Seielstad, (304) 456-2011. Exhibits, historical astronomical instruments, tours, films. Monday-Sunday mid-June through Labor Day.

Wheeling

Benedum Natural Science Center. Oglebay Park, 26003. Steven Mitch, (304) 242-3000 extension 261. Classes, public observing, films, planetarium shows, laser shows, observatory, special children's programs. Open Monday-Sunday.

WISCONSIN

Appleton

Northeast Wisconsin Stargazers (Newstar). 109 Skyline Drive, 54915. Bob Schmall.

Fall Creek

Beaver Creek Reserve. Box 94, 54742. Bob Elliott, (715) 877-2212. Public observing, observatory, open houses. Open first Sunday of the month.

Janesville

Rock Valley Astronomical Society. P.O. Box 1362, 53545. Douglas A. Thomson.

Madison

Madison Astronomical Society, Inc. 205 Cameo Lane, 53714-2514. David D. Weier, (608) 241-1444.

Washburn Observatory. 1401 Observatory Drive, 53706. (608) 262-3071.

Milwaukee

Milwaukee Astronomical Society. 188th and Observatory Road, New Berlin. (414) 542-9071.

University of Wisconsin-Milwaukee Planetarium. 1900 East Kenwood, 53211.

Stevens Point

University of Wisconsin-Stevens Point. Science Building, 740 Reserve Street, 54481. Randy W. Olson, (715) 346-2208. Tours, public observing, planetarium shows, observatory. Open Tuesday, Wednesday, and by reservation.

Williams Bay

Yerkes Observatory. P.O. 258, 53191-0258. Richard Dreiser, (414) 245-5555.

WYOMING

Casper

Casper Planetarium. 904 North Poplar Street, 82601. Rod Robinder, (307) 557-0310. Exhibits, planetarium shows. Open Monday-Sunday evenings only.

Cheyenne

Cheyenne Astronomical Society. 3409 Frontier Street, 82001. (307) 634-2509.

CANADA

Alberta

Royal Astronomical Society of Canada-Calgary Center. Calgary Planetarium, P.O. Box 2100, Station M, Calgary, T2P 2M5.

Edmonton Space Sciences Centre. 11211-142 Street, Edmonton, T5M 4A1. Russ Sampson, (403) 452-9100. Exhibits, historical astronomical instruments, space artifacts, tours, lectures, classes, public observing, planetarium shows, laser shows, IMAX theater, observatory, open houses, special children's programs. Open Tuesday-Sunday.

Royal Astronomical Society of Canada-Edmonton Centre. Mel Rankin, 4203-10613 Avenue, Edmonton, T6A LK7. Sponsors the 1988 Alberta Star Party.

British Columbia

Dominion Radio Astrophysical Observatory. National Research Council of Canada, Box 248, Penticon, V2A 6K3. Erika Rohner, (604) 497-5321. Exhibits, tours. Open Monday-Sunday.

Gordon Southam Observatory. 1100 Chestnut Street, Vancouver, V6J 3J9. David Dodge, (604) 738-2855.

Royal Astronomical Society of Canada-Vancouver Centre. Gordon Southam Observatory, 1100 Chestnut Street, Vancouver, V6J 3J9.

University of British Columbia. 2219 Main Mall, Vancouver, V6T 1W5. David Vogt, (604) 228-2802. Tours, public observing, observatory. Open Monday-Friday.

Okanagan Astronomical Society. 4100 25th Avenue, Vernon, V1T 1P4. Peter Kuzel, (604) 545-1226. Sponsors the Fifth Annual Mount Kobau Star Party.

Climenhaga Observatory. Department of Physics and Astronomy, University of Victoria, Victoria, V8W 2Y2. Russell Robb, (604) 721-7750. Tours, lectures, classes. By reservation only.

Dominion Astrophysical Observatory. National Research Council of Canada, 5071 West Saanich Road, Victoria, V8X 4M6. Chris Aikman, (604) 388-0001. Exhibits, historical astronomical instruments, public observing. Open Monday-Sunday.

Royal Astronomical Society of Canada-Victoria Centre. 801 Stanehill Place, RR #1, Victoria, V8X 3W9. A. Newton, (604) 478-8065.

Manitoba

Lockhart Planetarium. University of Manitoba, 380 University College, 500 Dysart Road, Winnipeg, R3T 2M8. Ian D. Cameron, (204) 474-9785. Planetarium shows. By reservation only.

Manitoba Astronomy Club. 190 Rupert Avenue, Winnipeg, R3B 0N2. Doug Knight, (204) 956-2830.

Manitoba Planetarium. Múseum of Man and Nature, 190 Rupert Avenue, Winnipeg, R3B ON2. (204) 956-2830.

Newfoundland

Royal Astronomical Society of Canada-St. John's Centre. P.O. Box 944, Mount Pearl, A1N 3C9. Peter Allston.

Nova Scotia

Burke-Gaffney Planetarium. Saint Mary's University, Department of Astronomy, Halifax, B3H 3C3. Laurie Reed, (902) 429-9780.

Royal Astronomical Society of Canada-Halifax Centre. 1747 Summer Street, Halifax, B3A 4J8. Douglas Pitcairn, (902) 463-7196. Sponsors Nova East '88.

Ontario

National Museum of Science and Technology. 1867 St. Laurent Boulevard, Ottawa, K1A 0M8. Mary Grey, (613) 991-3077. Exhibits, historical astronomical instruments, space artifacts, public observing, films, observatory. Open Monday-Sunday.

David Dunlap Observatory. University of Toronto, Box 360, 123 Hillsview Drive, Richmond Hill, L4C 4Y6. (416) 884-2112. Exhibits, tours, lectures, public observing. Open Tuesday and Saturday by reservation.

Royal Astronomical Society of Canada-Niagara Centre. 24 Hawthorne Avenue, St. Catharines, L2M 6A9. John Dekker, (416) 934-7210.

Doran Planetarium. Laurentian University, Sudbury, P3E 2C6. Doug Hallman, (705) 675-1151 extension 2222. Planetarium shows, special children's programs. Open Monday-Friday by reservation.

Science North Solar Observatory. 100 Ramsey Lake Road, Sudbury, P3E 5S9. Steve Dodson, (705) 522-3701. Public observing. Open Monday-Sunday.

Sudbury Astronomy Club. 859 Chestnut Crescent, Sudbury, P3A 5B3. Fred Boyer, (705) 560-3265.

McLaughlin Planetarium. 100 Queen's Park, Toronto, M5S 2C6. Thomas Clarke, (416) 586-5736. Exhibits, historical astronomical instruments, lectures, classes, planetarium shows, laser shows. Open Monday-Sunday.

North York Astronomical Association. 16 Beaufield Avenue, Toronto, M4G 3R3. Andreas Gaga, (416) 922-6244. Sponsors Starfest '88.

Ontario Science Centre. 770 Don Mills Road, Toronto, M3C 1T3. Ivan Semeniuk, (416) 429-4423. Exhibits, public observing, planetarium shows. Open Monday-Sunday.

Royal Astronomical Society of Canada-Toronto Centre. McLaughlin Planetarium, 100 Queen's Park, Toronto, M5S 2C6. Guy Nason, (416) 222-4814.

Quebec

Dow Planetarium. 1000, rue de St. Jacques West, Montreal, H3C 1G7. Pierre Lacombe, (514) 872-4530. Planetarium shows. Open Monday-Sunday.

La Societe D'Astronomie de Montreal. 7110 8th Avenue, Montreal H2A 3L9. Marc Gelinas, (514) 453-0752.

Royal Astronomical Society of Canada-Quebec Centre. P.O. Box 9396, Sainte-Foy, G1V 4B5. (418) 626-9592. Sponsors the Thirteenth Annual Association des Groupes d'Astronomes Amateurs Congress.

Saskatchewan

University of Saskatchewan Observatory. Saskatoon, S7N OWO. Stan Shadick, (306) 966-6434.

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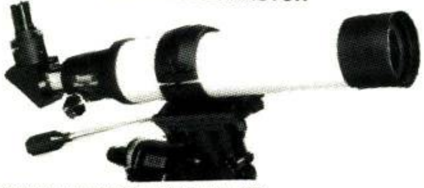

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Amateur Astronomy by Video

Schmidt Cassegrain Telescope Astro Video Tapes, (Roger W. Tuthill, Inc., 11 Tanglewood Lane, Department A, Mountainside, NJ 07092, 1-800-223-1063), $49.95 each.

With the phenomenal growth of home videocassette recorders, countless rental outlets and mail order catalogs have emerged featuring tapes on virtually every subject imaginable. Now Roger W. Tuthill, Inc., has broken into the home video market with two instructional videotapes designed for Schmidt-Cassegrain telescope users and amateur astrophotographers.

Video Tape 1 shows the viewer the basics of setting up and operating a Schmidt-Cassegrain telescope (SCT). This tape runs for fifty-one minutes. The second cassette describes the application of SCTs to astrophotography and runs approximately thirty minutes.

Tuthill uses a Celestron C8 for demonstration purposes, but the information contained in each cassette is equally applicable to the line of Meade or Bushnell SCTs in all sizes. Owners of refractors or Newtonians won't get as much out of the tapes, especially if their telescopes are mounted on German-type equatorials. Perhaps future versions will cover the use of these types of scopes and mounts in more detail.

Tuthill's instructions for mounting and collimating finders, focusing, using setting circles, seeing and transparency, eyepieces, and safe solar viewing (including H-alpha prominence viewing) generally apply to all types of scopes.

Owners of Schmidt-Cassegrain telescopes can now get more out of their scopes with instructional videocassettes from Roger W. Tuthill. Photo by Jacques Guertin.

SCT owners will find Tuthill's demonstration of the initial setup of fork-mounted scopes, the description and operation of their controls, polar alignment, and dew prevention particularly useful. But the SCT scope collimation demonstration alone is worth the price of the cassette. Transporting your SCT to a suitable site can loosen the SCT's secondary mirror, rendering it nearly useless for observing. Returning the entire tube assembly to the manufacturer is expensive and time-consuming. Tuthill shows how to handle that problem with nothing more than an Allen wrench, a Christmas tree ornament, and a little patience.

The sequence on setting circles needs some clarification. To establish accurate right ascension settings, Tuthill selects a bright summer star — Vega — and sets his R.A. circles to 18h36m, which he obtains from the annual *Observers Handbook* of the Royal Astronomical Society of Canada. However, he neglects to say that before you set the coordinates of Vega on the R.A. setting circle, you must *first* center Vega in the field of view of your scope. No doubt this will confuse many viewers. Also, the bolts that attach his C8 to its equatorial wedge are 3/8" in diameter, not 5/16" as stated, but this is a minor point.

These oversights are clarified in a letter that accompanies both tapes. The same letter also contains a list of topics covered and the approximate tape counter numbers so specific subjects can be quickly isolated without having to view the entire tape. The guide did not work very well with my VCR, but it may on yours.

The tapes are not intended to replace owner's manuals, but they do a fine job of supplementing them. Charts, photos, and accessories effectively get Tuthill's points across, points that might otherwise be overlooked in reading the sometimes vague and misleading operating manuals of some of these instruments. Although you can always reread the manual, the cassette allows you to *watch* a procedure and then replay it until you've perfected the technique. What's more, the video is spiced with humorous anecdotes instead of dry facts and figures, which you're apt to find in some manuals.

Tape 2, which attempts to introduce amateur astronomers to the various methods and accessories used in astrophotography, unfortunately does not succeed as well as Tape 1. In fact, it barely scratches the surface of the subject. The tape contains hints on basic photo techniques, initial film choice, recording data, reciprocity failure, bracketing exposures, cold cameras, film hypersensitizing, star trailing, piggyback, and prime-focus photography. It also touches on proper guiding, camera choices, and useful accessories, but it does not cover high-speed, wide-angle Schmidt camera photography.

That's still a lot of data, but it's not quite enough. The production is more a quick survey of astrophotographic techniques, and though the program provides a good foundation for beginners, it is apt to lead them into no man's land.

Cold camera and film hypering devices are briefly described, but actual samples of them would have greatly clarified this segment and made a more interesting presentation. Tuthill concentrates on black-and-white films, which is fine, except that he ignores the newer color slide films currently being used successfully by many amateur astrophotographers. Color slide film can be processed commercially with good to excellent results.

The usefulness of nebular filters is discussed but the advantages of photo visual color filters, especially as applied to black-and-white films, which he seems to prefer, goes unnoticed. These filters are very effective in bringing out faint planetary details.

Two different off-axis guiders are demonstrated, but he neglects to mention that these devices are useful only if a bright enough guide star can be located within their field of view, which is not always the case.

The parade of accessories seems almost endless. Most of them are adequately described but unfortunately at the expense of explaining the fine points of astrophotography. Intermediate and advanced astrophotographers are familiar with the advantages and disadvantages of accessories, but the beginner, to whom this cassette seems to be aimed, is not. Tuthill recommends books, an atlas, pamphlets, and magazines such as ASTRONOMY and *Sky & Telescope*. However, the beginner would probably find the selection of books on astrophotography over his head. Other up-to-date works on the subject are better tailored to the needs of the novice and should have been included.

Obviously there is no way of cramming all the details of astrophotography into a thirty-minute videocassette. Tuthill should have devoted at least as much time to this cassette as he did to Tape 1. Nevertheless, it is still worth viewing because it contains a considerable amount of valuable information.

Both tapes were directed and edited by Bruce W. Tuthill and include eye-catching graphics, vivid color, and an upbeat soundtrack by Raul Colon. Other than the attention to commercially available hardware in Tape 2, I never got the impression I was watching a lengthy commercial. Besides, the practical value of the information far outweighs the commercial aspects.

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— Donald Trombino

Astronomy Videos for the Classroom

Planets of Gas, an educational video, (produced by Films for the Humanities and Science, P.O. Box 2053, Princeton, NJ 08543), VHS and Beta format, $149; U-Matic, $199.

Mars, the Red Planet, astronomy videotapes (produced by John Pickering, Stellar Studies, 36 Franfort Street, Rochester, NY 14608), includes videotape and workbook.

Planets of Gas is the fifth part of a seven-part British-made educational astronomy video series designed to provide introductory material on the solar system to students in grades seven through twelve. Other programs in the series are *Children of the Sun, Mercury and Venus, The Blue Planet, The Angry Planet, The Search for Planet X*, and *Are We Alone?*.

Planets of Gas hits the high points of what planetary scientists have learned about Jupiter and Saturn from Earth-based research and space probes. The message is that these planets are dynamic systems of gas and storms, intense electromagnetic fields, and diverse satellites — mini-solar systems in their own right.

The classic scientific understanding of these two gas planets are presented in sharp contrast to modern views. We consider first the blurred disks Galileo saw in his crude telescope and then leap into the future by witnessing the enthralling time-lapse film of images of Jupiter's swirling Great Red Spot and Saturn's spinning rings, taken by *Voyager* spacecraft.

Interviews with planetary scientists, such as Brad Smith from the department of planetary science at the University of Arizona, lend a credibility to the program teachers will appreciate. There are also clear, vivid graphics of a star's passage behind Saturn's rings, the vapor cloud expelled by Io's many volcanoes, and an impressive animation of Jupiter's enormous magnetic field, which looks like a slowly swaying cage surrounding the planet.

If *Planets of Gas* reflects the quality of the other episodes, the entire series can be recommended for introductory astronomy courses at the middle-school and high-school levels.

Although not as polished as the British program, Stellar Studies has designed a unique series of videotapes and educational materials specifically to aid science teachers in presenting introductory information about the solar system to grades one through twelve. John Pickering, a planetarium special effects producer, produced the series in an effort to bring the educational impact of the planetarium into the classroom. *Mars, the Red Planet*, is one of three available video tapes. The others are *The Moon: Our First Frontier in Space* and *The Solar System*.

Each tape features three presentations of the same topic but at progressively advanced levels. According to Pickering, this allows a teacher to select the level best suited to the aptitude of the class.

Mars covers the most recent research into the planet's climatologic and geologic history. Past and future space missions to Mars are discussed, as is the question of life on Mars.

In the first presentation, called "Footprint I" in the accompanying literature, the viewer is introduced to "Captain Terri and Captain Mike" who control the helm of a spaceship on its way to Mars. Before arriving at the Red Planet, Captains Terri and Mike give the viewer a Mars profile, which covers early discoveries by astronomers, how Mars looks in a telescope, and what space probes revealed about the planet's atmosphere and surface. The two captains — who deliver their lines a little like stilted newscasters — also introduce the viewer to "Mr. Mars," the Red Planet personified, who speaks in a basso profundo voice and invites everyone to come visit him. Unsure as to whether or not this format is effective with children, I asked my daughter, who is in the first grade, what she thought of Mr. Mars. She assured me she didn't mind a talking planet and professed to like the two smiling spaceship captains.

The second level, "Footprint II," continues with the friendly space-pilot approach and covers the same topics, but there is no Mr. Mars and the science information is more detailed. In "Footprint III" we encounter the same friendly hosts (now just Terri and Mike), but the spaceship helm is now more of a computer center, and the script is even more advanced and sprinkled with additional science terminology.

The workbooks supplied with each videotape in the series contain supplementary material and are also divided into different aptitude levels. For example, the primary level contains word games and pictures to color, the advanced level offers vocabulary questions and a few math problems.

Despite the wooden acting, the science information is sound and the graphics are quite good. Moreover, the three different aptitude levels placed back to back on one videotape make sense because teachers can apply the same material to different classes without forcing the school into ordering more than one tape. This makes teacher-sharing of a single resource possible.

If you're teaching astronomy or Earth science, these educational videos bear investigating, especially if your science department is low on audio-visual material as well as funding.

— Jeff Kanipe

A Challenging Simulation Program

Space MAX, software for IBM compatible computers, (Final Frontier Software, 18307 Burbank Avenue, Suite 106, Tarzana, CA 91356, 1987), $49.95 (copy protected), $59.95 (copy to hard disk or floppies).

Space MAX is a simulation program that puts you in charge of assembling and operating an Earth-orbiting space station. You have the task of selecting the optimum launch vehicles, cargo, crew, and supplies; launching them into orbit; and assembling them into an efficient and productive system while staying within a limited budget. Once the space station is operational, you can begin production of commercial compounds and materials in microgravity to help pay for the station.

This is not an adventure or arcade game by any definition. *Space MAX* requires you to make hundreds of decisions and rates you on your performance at frequent intervals. Simultaneously, you are at the mercy of life-threatening emergencies, foul weather at the various landing and launch sites, equipment malfunctions, and other unexpected crises. There is a choice of five levels of difficulty, from mildly frustrating to "no wonder our taxes are so high!"

Space station personnel gain experience while in orbit and operate more efficiently until they have spent ninety days there, after which their efficiency drops off. Crew men can die, get sick, or go on strike. You have to keep union rules in mind when equipping the station with food, recreation, and medical facilities. The crew also gets every seventh day off except during emergencies.

The 137-page manual gives a detailed overview of space station construction and operation as well as

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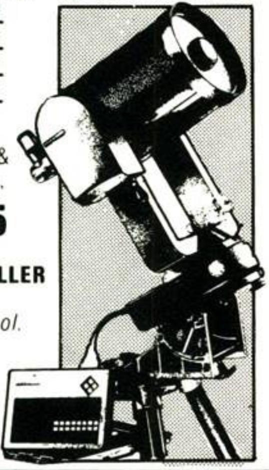

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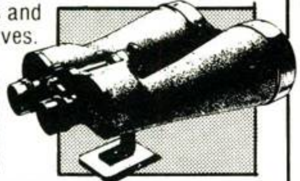

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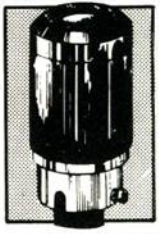

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how to run the simulation. A run in progress can be saved on disk so you can later continue where you left off. You can also print hard copies of your daily status reports. I suggest you study well some of the more critical portions of the manual to avoid spending your first hour or so making a complete fool of yourself as I did.

Space MAX let me send up a completely loaded heavy-lift launch vehicle. However, when I tried to assemble the modules, I found out I didn't have any assembly crew up there to do the work. So I had to send a crew up in a shuttle along with some additional modules. And by the way, you get penalized for wasted time and supplies!

However, there is a limit to how far *Space MAX* will let you go. For example, the program will not let you do totally rash things like overload your spacecraft or activate your space station without solar panels for power. The program expects the user to take his space station scenarios seriously.

If you are looking for a "shoot-em-up," this is not it. But if you are a simulation maven and like intricately detailed software that demands a lot of concentration, then *Space MAX* is the package for you.

— *James Bailey*

Astrophysics

Nuclear Astrophysics, edited by W. Hillebrandt *et al.*, (Springer-Verlag, 1987), ISBN 3-540-18279-9, hardcover, 346 pages, $38.

Cosmology

Observational Cosmology: Proceedings of the International Astronomical Union, China, 1986, edited by Adelaide Hewitt, Geoffrey Burbidge, and Li Zhi Fang, (D. Reidel, 1987), ISBN 90-277-2475X, hardcover, 854 pages, $149.

Galaxies

Physics of the Galaxy and Interstellar Matter by H. Scheffler and H. Elsasser, (Springer-Verlag, 1987), ISBN 3-540-17314-5, hardcover, 492 pages, no price given.

Mathematics

Statistical Analysis of Spherical Data by N. I. Fisher, T. Lewis, and B. J. J. Embleton, (Cambridge University Press, 1987), ISBN 0-521-24273-8, hardcover, 329 pages, $65.

Observing

The Amateur Astronomer's Handbook: A Guide to Exploring the Heavens, third edition, by James Muirden, (Harper & Row, 1987), ISBN 0-06-091426-2, paperback, 472 pages, $10.95.

A Reference Catalogue and Atlas of Galactic Novae by Hilmar W. Duerbeck, (D. Reidel, 1987), ISBN 90-277-2535-7, hardcover, 212 pages, $48.

Solar Eclipses, 1991-2000, by Alan D. Fiala, James A. DeYoung, and Marie R. Lukac, Circular No. 170, (U.S. Naval Observatory, 1986), paperback, 43 pages.

SS Cygni Light Curves, 1896-1985, prepared by Janet A. Mattei *et al.*, AAVSO Monograph 1, (American Association of Variable Star Observers, 1985), paperback, 40 pages.

U Geminorum Light Curves, 1855-1985, prepared by Janet A. Mattei *et al.*, AAVSO Monograph 2, (American Association of Variable Star Observers, 1987), paperback, 42 pages.

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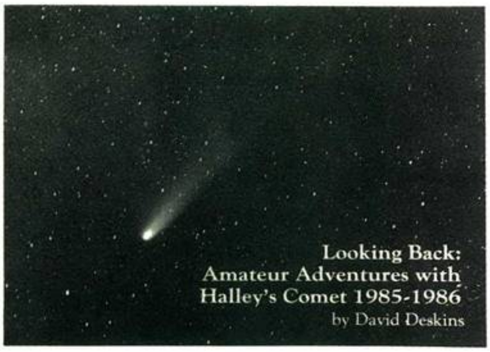

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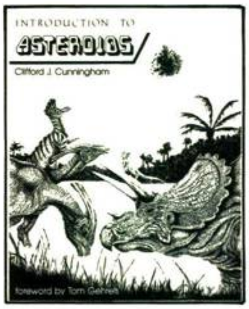

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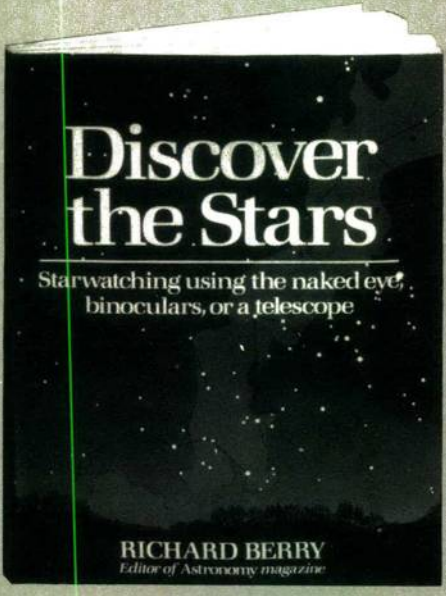
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ASTRONOMY
AstroNews

Quasars Triggered by Galactic Collisions

Three independent discoveries conducted by teams from various universities and the National Optical Astronomy Observatories appear to confirm that quasars can be triggered when galaxies collide.

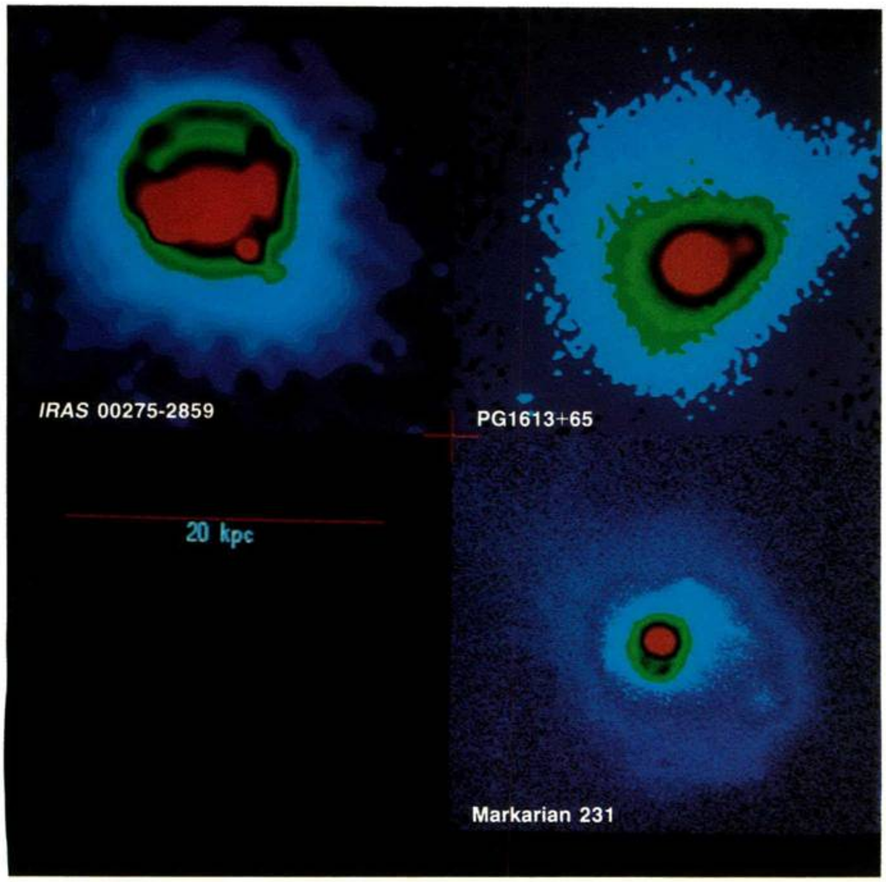
Computer-processed images of three relatively nearby quasars — *IRAS* 00275-2859, PG1613+65, and Markarian 231 — appear to show three consecutive stages of quasar ignition. Each quasar represents a different degree of interaction between the quasar's galactic host and a passing companion galaxy. *IRAS* 00275-2859 is about to collide with a second galaxy nucleus, PG1613+65 has begun to collide with the companion nucleus, and Markarian 231 has completed its collision.

Astronomers have long suspected that quasars are the products of galactic collisions. The collision drives interstellar gas into the two galaxies' common centers, fueling the gravitational engine — probably a massive black hole. This process generates tremendous amounts of energy and could account for the extreme brightness of quasars — typically one hundred times brighter than our Galaxy. Some astronomers believe quasar activity may, in fact, occur at an early stage in the lives of active galaxies.

IRAS 00275-2859 represents the first stage of an encounter between two galaxies before the host galaxy has been significantly distorted by tidal forces but after the shocks of the collision have set off bursts of star formation in the host galaxy. The quasar is only about 3 parsecs in diameter and its host galaxy is about 35,000 parsecs in diameter. The second nucleus, which appears fainter because of the glare from the quasar, is about 11,000 parsecs from the quasar.

The second stage in the quasar-ignition sequence is represented by the image of PG1613+65, which shows the collision beginning in earnest. Tidal forces appear to have sheared away one quadrant of the host galaxy, and a well-defined tail, probably composed of stars, can be seen. The quasar and the second nucleus are separated by less than 6,000 parsecs. According to Howard Yee of the University of Montreal and a member of the research team, "It's extremely rare to catch the companion interacting this closely with the quasar. We believe there is something different about this one. The whole system is in some fantastic commotion."

The collision appears to be complete as seen in the image of Markarian 231. Clas-



Computer-processed photos derived from independent discoveries may show three steps in the ignition of quasars. All three photos are presented in the same 20-kiloparsec scale. In the photo at upper left a quasar nears collision with a second nucleus (which cannot be seen in the photo because of the distance and the glare from the quasar). The image at upper right shows both the quasar and the second nucleus (the "lump" at the two o'clock position). The shape of the galaxy, as seen in the outer blue contours, is highly distorted. At bottom right the collision is complete. A tidal tail to the right of the nucleus and nebulous streaks indicate gravitational interactions of the merged galaxies. National Optical Astronomy Observatories photo.

sified as a Seyfert galaxy — a galaxy with an active nucleus that many astronomers believe is a less energetic form of a quasar — Markarian 231 displays a tidal tail and nebulous streaks, which some astronomers interpret as a blast wave moving out from the nucleus.

The distances to these quasars range from about 4 billion light-years for *IRAS* 00275-2859 to 1 billion light-years for Markarian 231. Thus, these quasars are seen in comparatively recent times in the history of the universe. Such collisions imply that quasars continue to be ignited by galactic collisions long after the first galaxies formed, although the frequency of collisions is lower today because galaxies have moved farther apart as the universe has expanded.

Still unclear is whether a quasar "engine" exists in the host galaxy, inactive but waiting to be fueled by a passing galaxy, or whether the collision creates the quasar.

"The common view now is that maybe all this luminosity is coming from nuclear regions," explained Patricia Vader of Yale University and a member of the research team that studied the *IRAS* quasar. "Studies of nearby active galaxies show nuclei that look a lot like quasars. In a few of [these active galaxies] you see two nuclei, where a quasar is being formed. As the initial star burst subsides and gas is dumped on the quasar, the quasar gets more luminous, and you begin to see it. Either the quasar is formed during the collision by a huge central concentration of mass, or the quasar is already there and simply fueled by the fresh gas input."

Space Not a Priority for Presidential Candidates

When the presidential candidates were invited to present their views on U.S. space policy to the House Science, Space, and Technology subcommittee in February, none of the candidates appeared. Apparently, the presidential candidates did not think space was an issue the public is concerned about in the 1988 election.

The subcommittee held two special hearings in February: one for the Democratic candidates in Iowa City shortly before the Iowa caucuses, and one for the Republican candidates in Durham, New Hampshire, before the New Hampshire primary.

The subcommittee expressed disappointment that no candidates appeared to testify. "We are about to embark on projects such as the Space Station and the national aerospace plane that the next administration will guide to completion," said subcommittee member Representative Robert Walker (R-Pa.). "These projects are vital to our future in space and the public should know how these programs and other space efforts will be handled by the next president."

Space has not been as visible an issue as it should be in the 1988 presidential campaign, said subcommittee member Representative Dave Nagle (D-Iowa), because the candidates haven't received any inquiries about space policy from the press. But, he added, "if the candidates didn't think it was important enough to be here, we've got a lot of educating to do."

Even without the candidates, however, the subcommittee received testimony on national space policy from scientists at the University of Iowa and the University of New Hampshire. In New Hampshire the discussion focused on the proposal for a national space advisor, who would advise the president on space policy. "Our nation's scientific, technological, engineering, and educational competitiveness will to no small degree depend on the effectiveness of this advisor," said retired Admiral J. B. Mooney, Jr., a professor at the University of New Hampshire.

In Iowa scientists gave their opinions on manned versus unmanned space missions. James Van Allen of the University of Iowa advocated unmanned vehicles to re-establish the U.S. space program.

— Reported by Bruce Japsen in Iowa and R. Scott Teets in New Hampshire

Theory of Galaxy Formation Altered

Recent observations of young galaxies have changed the way astronomers believe galaxies form. Until December 1987 astronomers believed galaxies formed during a time 10 billion to 15 billion years ago called the "epoch of galaxy formation." However, observations published last December by a team of scientists show what the astronomers believe are galaxies in the process of forming.

Don York and Brian Yanny of the University of Chicago, Don Hamilton of the National Optical Astronomy Observatories, and Robert A. Schommar and Theodore B. Williams of Rutgers University made the discovery while interpreting data from a three-year survey of quasars. As far back as the 1960s York and his colleagues observed extragalactic gas clouds lying between quasars and Earth. By studying the spectra of quasars behind these clouds, the astronomers found the clouds contained elements similar to those in haloes of nearby galaxies. Therefore, the astronomers concluded that the gas clouds were haloes of distant galaxies. The galaxies are not visible directly because they are faint; only by chance alignment with quasars can they be observed.

Last autumn, however, the astronomers found spectra indicating that some of these haloes of gas were extremely turbulent, containing gas moving at velocities of several thousand kilometers per second. "Turbulence in a galaxy is caused by supernova explosions, which go hand in hand with star formation," said York.

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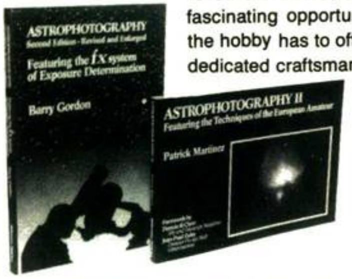
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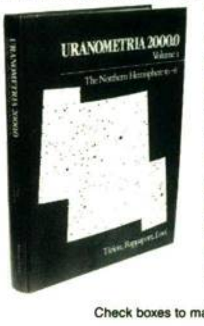

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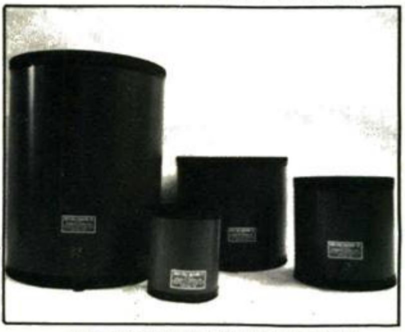
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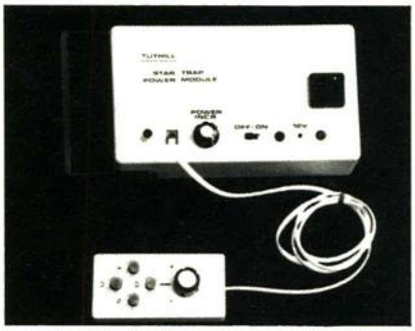

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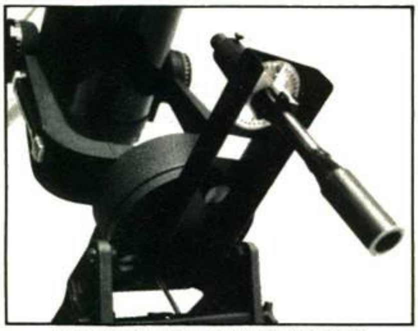
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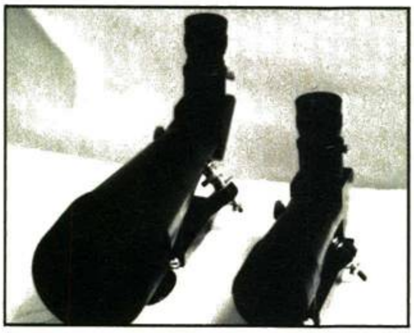
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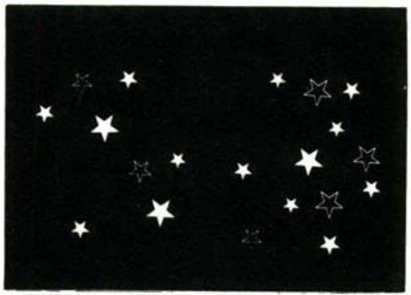
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"And star formation is most active when galaxies are quite young. This suggested to us that the gas may not be haloes but distended, young galaxies that are still in the process of condensing into their final form."

The astronomers will continue collecting data on these young galaxies. Can any conclusion be drawn from their 1987 research? According to York, "It looks as if galaxies form at different times in different places. And they form closer to home than we thought." To be sure, York said, astronomers have some rethinking to do: "It seems there never really was an epoch of galaxy formation."

AAS Hosts Teachers' Workshop

For the first time in its eighty-nine-year history the American Astronomical Society sponsored a workshop for high school teachers during the society's winter meeting in Austin, Texas, last January. Entitled "Astronomer for a Day: A Special Workshop for High School Teachers," the two-day workshop immersed over sixty teachers in current astronomy research and the goings-on at a professional scientific meeting.

During his welcoming address, Charles Tolbert of the University of Virginia and chairperson of the society's task group on education in astronomy encouraged the teachers to mix and mingle with the astronomers and to ask lots of questions.

"Our intent," said Tolbert, "is to make a bigger impact on the education community when the AAS arrives in town. Wherever the AAS meets, we will conduct a similar workshop in that area."

Society members presented brief introductory talks to give teachers an overview of modern astronomy. Tolbert spoke about the solar system's place in the universe and briefly touched on some of the components of the universe, such as asteroids, double stars, and galaxies. Mary Kay Hemenway of the University of Texas showed slides of the Sun photographed in different wavelengths and explained some of the basics of spectroscopy. Stellar evolution and current findings and theories concerning supernova 1987A were covered by James Sweitzer, assistant director of the Adler Planetarium.

The following day teachers attended the invited talks, paper sessions, and panel discussions and had the chance to discuss research with astronomers face to face. The society also scheduled astronomers to give twenty-minute presentations of their research to the teachers. These covered such topics as the Pluto-Charon eclipse events, coronal holes, and supernova 1987A.

Similar workshops will be conducted at the June 1988 AAS meeting in Kansas City, Missouri, and next year in Ann Arbor, Michigan.

ASTRONOMY AstroCalendar

April 23
Astronomy Day Celebration (exhibits, talks, shows, demonstrations, and a star party sponsored by the Northwest Suburban Astronomers), Hoffman Estates, Illinois. Contact: Bob Long, 4960 Chambers Drive, Barrington, Illinois 60010. Phone: (312) 991-7432.

April 23
15th Annual Astronomy Day. Contact: Gary E. Tomlinson, Chaffee Planetarium, 54 Jefferson Avenue SE, Grand Rapids, MI 49503. Phone: (616) 456-3985.

April 23
New England Astro-Fest I (commercial exhibit of astronomy-related products sponsored by New England Astro-Optics, Inc.), Bradley Ramada Inn at Bradley International Airport, Windsor Locks, Connecticut. Contact: New England Astro-Optics, Inc., Astro-Fest I, P.O. Box 834, Simsbury, CT 06070.

April 26-29
25th Space Congress (sponsored by the Canaveral Council of Technical Societies), Cocoa Beach, Florida. Contact: Leslie Neihouse, P.O. Box 1333, Cocoa Beach, FL 32931. Phone: (305) 783-0220.

May 7
Astronomy Day (displays, video and planetarium programs, a telescope-making workshop, and a starwatch sponsored by the Wilderness Center Astronomy Club), Wilmot, Ohio. Contact: Robin Bill, 558 Canford Avenue NW, Massillon, OH 44646. Phone: (216) 833-9399 (evenings).

May 21-22
Space Expo (spacecraft exhibits), Cradle of Aviation Museum, Garden City, New York. Contact: J. Stoff, Cradle of Aviation Museum, Museum Lane, Mitchel Field, Garden City, NY 11530. Phone: (516) 222-1190.

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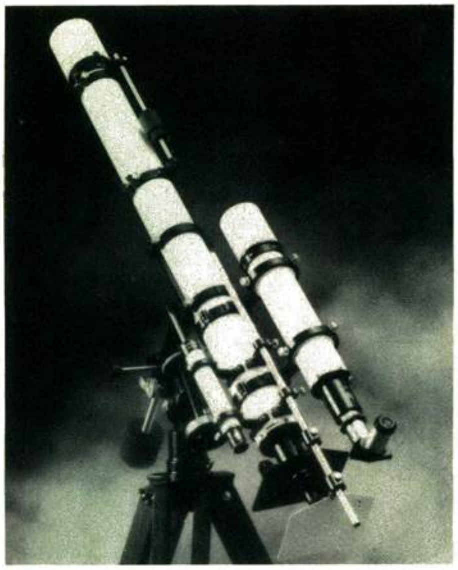

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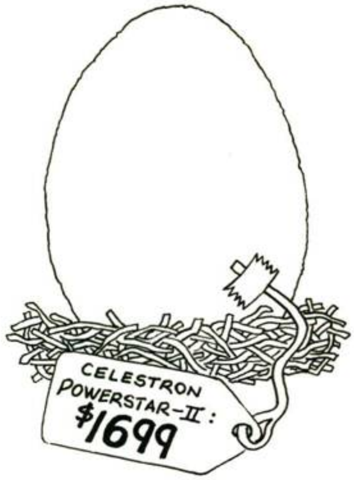

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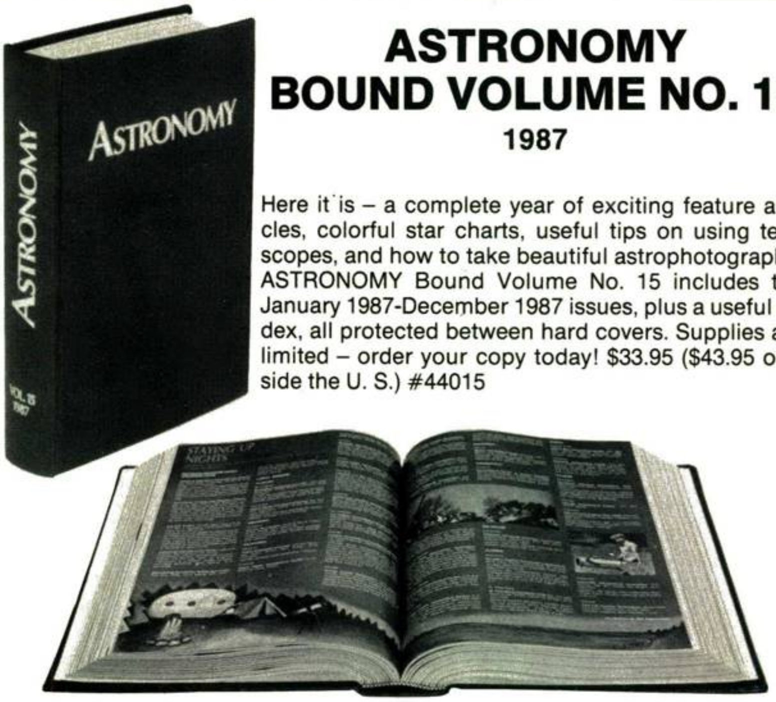

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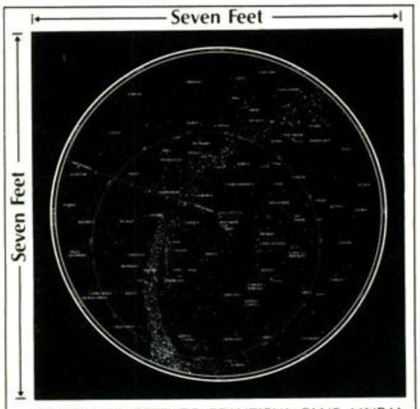

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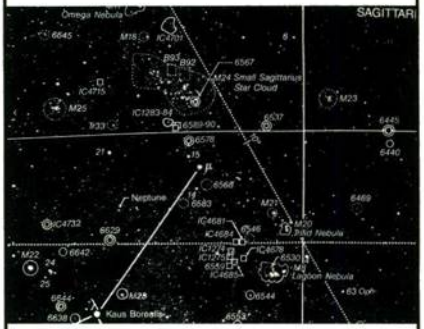

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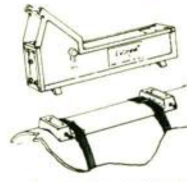

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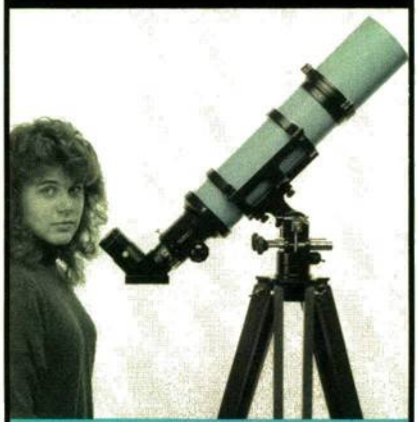

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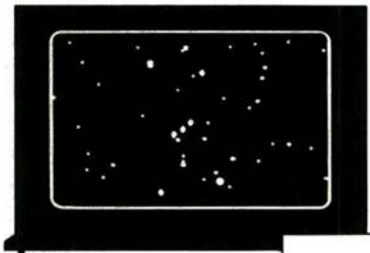

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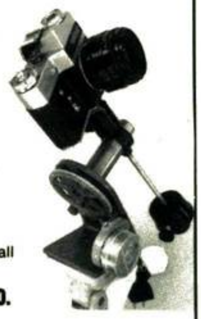

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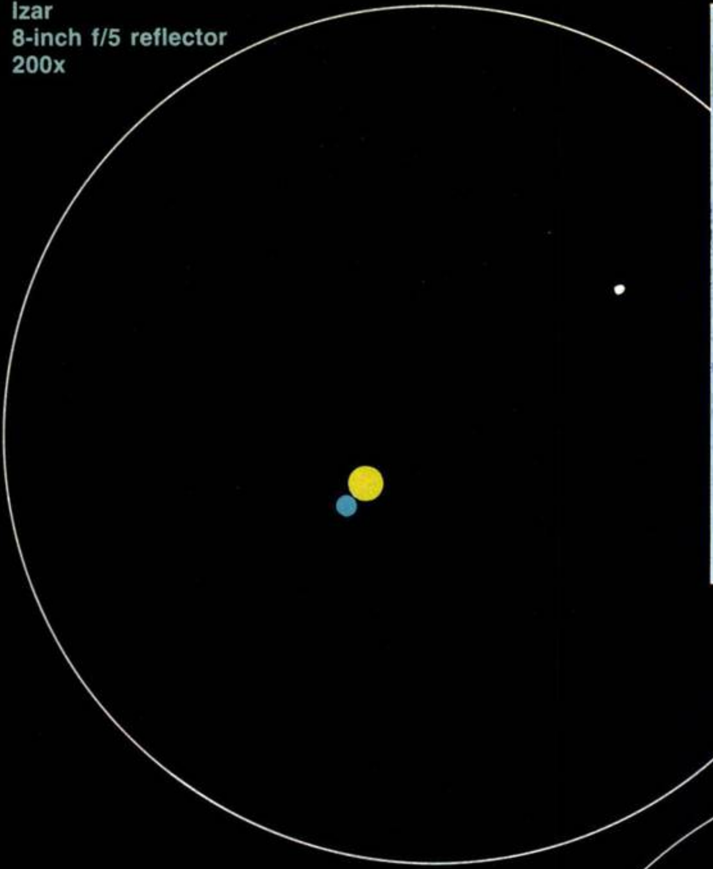

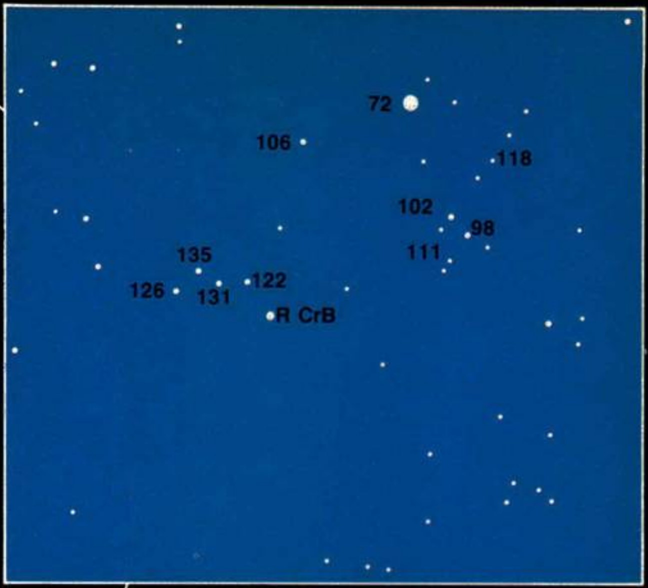

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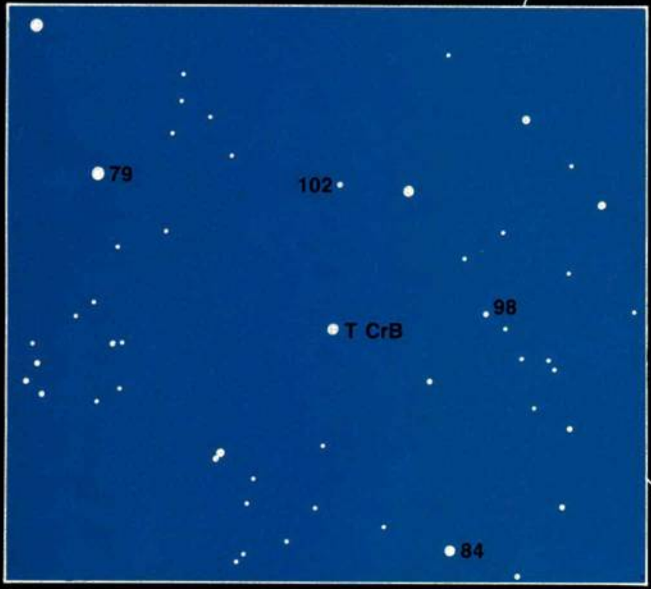
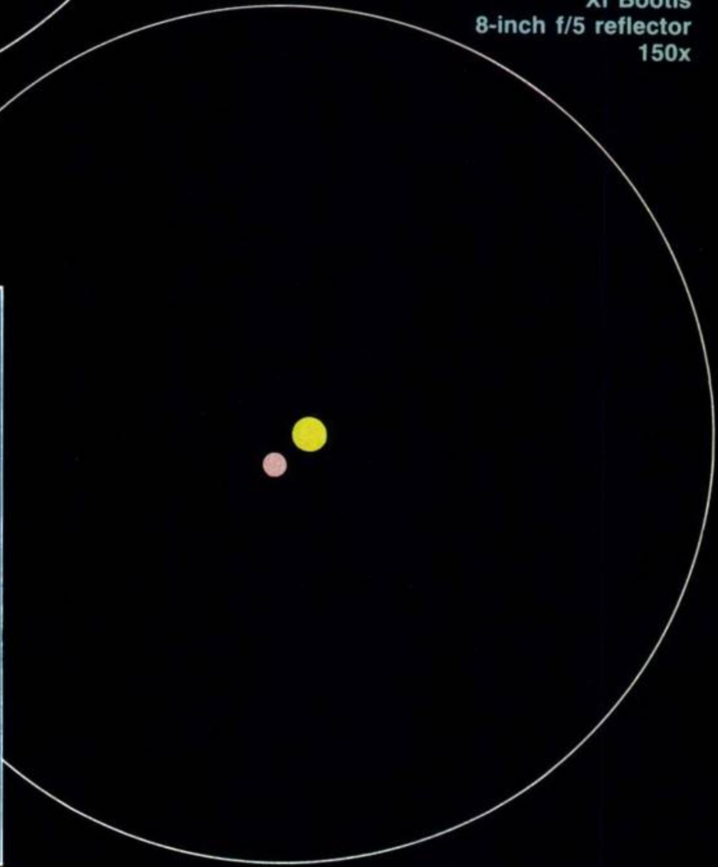




Top left: A lovely double star with yellow and blue components, Izar (Epsilon [ε] Bootis) can be split in small telescopes at high magnification. This drawing shows Izar as it appears in an 8-inch f/5 reflector at 200x. Sketch by James Mullaney.

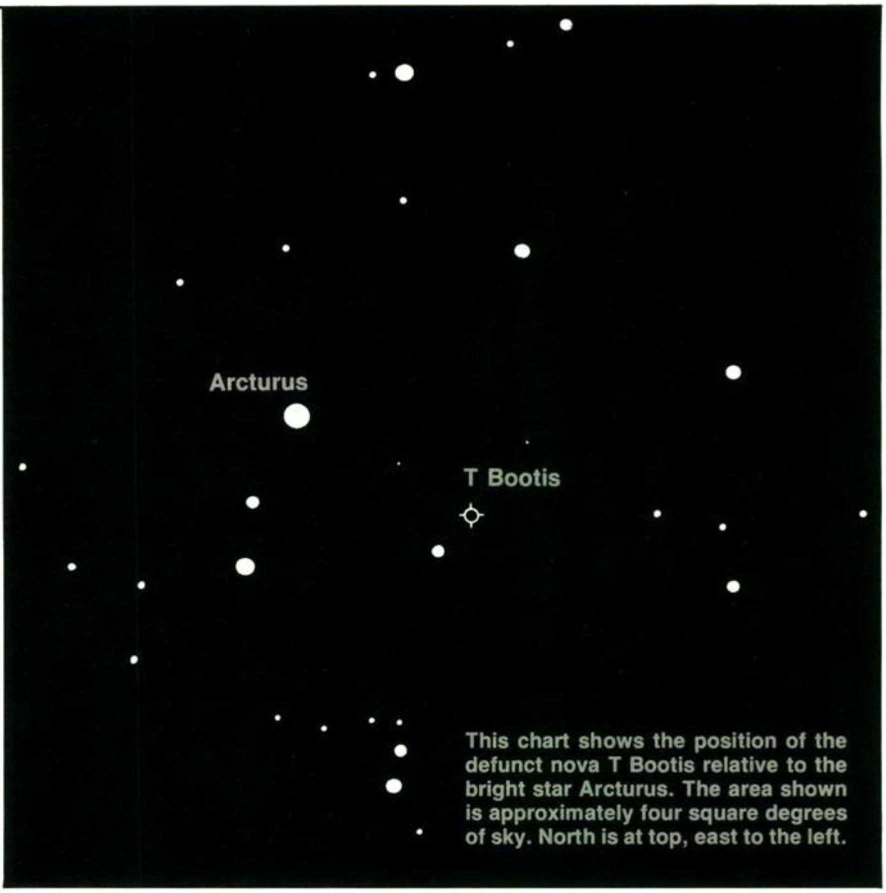
Top right: Variable star R Coronae Borealis dims for several months every two to four years. This chart covers approximately one square degree of sky. Numbers indicate magnitudes (with decimal points omitted) for stars in the same field of view.

Above left: T Coronae Borealis normally glows at 10th magnitude but has twice flared in brightness. This chart shows one square degree of sky around the variable. Numbers indicate magnitudes (with decimal points omitted) for stars in the same field of view.

Above right: Easier to split into component stars than Izar is the binary star Xi (ξ) Bootis. This object contains a yellow primary star and a rose-colored secondary. Sketch made by James Mullaney with an 8-inch f/5 reflector at 150x.

The Backyard Astronomer

A Slew of Springtime Stars



This chart shows the position of the defunct nova T Bootis relative to the bright star Arcturus. The area shown is approximately four square degrees of sky. North is at top, east to the left.

The first time you look up at the dark night sky the stars look pretty much the same, except for differences in brightness. But if you look closer, especially with a pair of binoculars or a small telescope, you'll see that stars are quite different from one another. Each star has its own combination of color, brightness, and behavior, which make it as unique as each person on Earth.

Take, for example, the springtime constellations Bootes the Herdsman and Corona Borealis the Northern Crown. These adjacent star groups contain a number of contrasting star types, including giant stars, double star systems, a defunct nova, and freak variable stars that seem to flare or dim in brightness unpredictably.

In Bootes a bright yellow beacon shining at magnitude −0.06, **Arcturus** (Alpha [α] Bootis), is not only the brightest star in the area but also the fourth brightest star in the sky. It marks the base of the central figure of Bootes, a kite-shaped outline of stars spanning 20° of declination.

Arcturus reaches its highest point in the sky and therefore its best visibility at midnight on April 27. When you next go out observing, take a pair of binoculars or a small telescope with you and aim it at Arcturus around midnight. With optical aid you can get a closer look at Arcturus and examine the star's color closely. Arcturus will appear bright enough in a telescope for you to detect a hint of orange along with the predominant yellow.

Arcturus is yellow-orange because it is a relatively cool star. The surface temperature on Arcturus is approximately 4200 kelvins; the Sun is 5800 kelvins. Arcturus may be cooler than the Sun, but it is also twenty-five times larger, with a diameter of 32 million kilometers. This star is a so-called Population II giant, a large star that lies outside of our Galaxy's disk in the Milky Way's halo. The distance to Arcturus is 10.5 parsecs, or some 325 trillion kilometers (one parsec equals about 31 trillion kilometers).

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

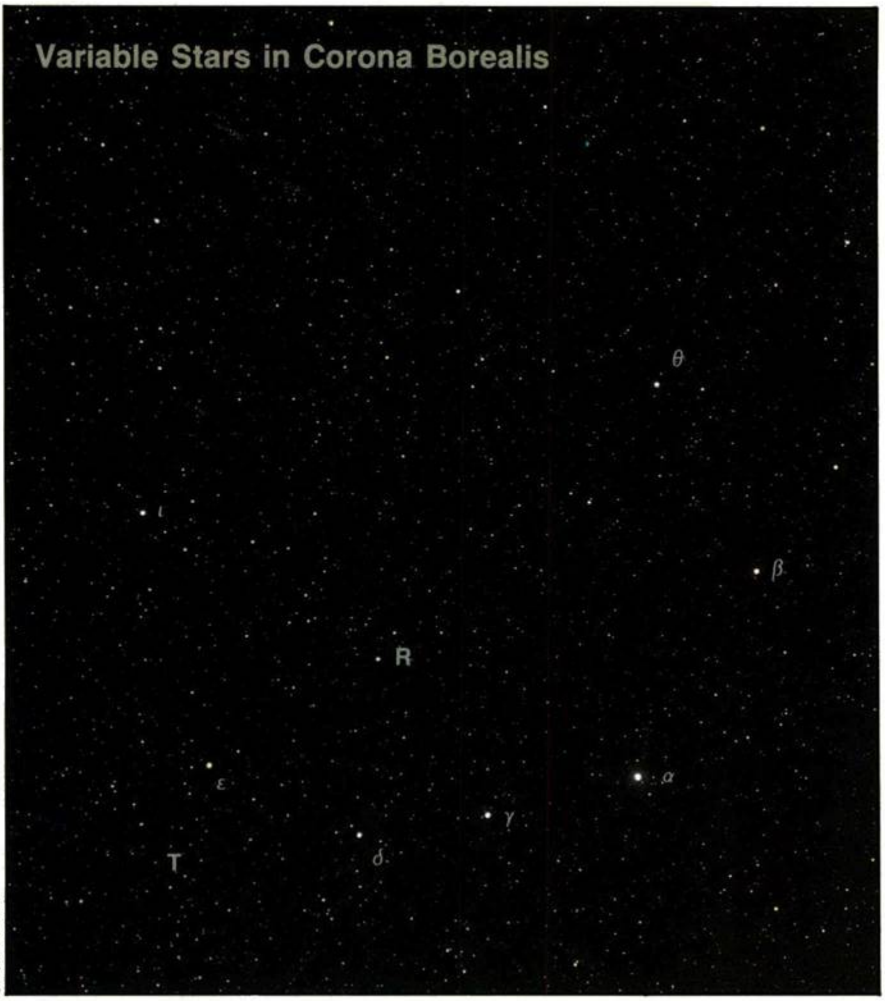
Arcturus sounds as if it's far away. In human terms it is. But relative to the size of the Milky Way Galaxy, Arcturus is almost in our backyard. How can it be a member of the outer Galaxy? Arcturus is currently slicing through the disk component of our Galaxy in its elliptical orbit and will it eventually move well away from our galactic neighborhood. Because of the star's closeness and its high-speed motion through the Galaxy, Arcturus' motion relative to the background stars —called proper motion — is 2.3″ each year. But this proper motion is slight: over the course of 835 years this motion carries the star over a distance equal to the diameter of the Full Moon.

The second brightest star in the kite of Bootes is **Izar** (Epsilon [ε] Bootis), which lies 10° northeast of Arcturus and some 46 parsecs away. Because Izar is over four times more distant than Arcturus, Izar's proper motion is almost immeasurably small. To the naked eye Izar is a solitary yellowish star shining at magnitude 2.3 that looks like a pale version of Arcturus. In reality, however, Izar is much brighter than Arcturus: its great distance only makes it appear fainter.

If you aim your telescope at Izar, you'll discover Izar is a beautiful double star. The brightest member of the pair is a magnitude 2.5 star with a yellowish cast; the secondary star glows at magnitude 4.9 and is blue in color.

The gap between Izar's two components is 2.8″, which makes the pair a tough test for a 3-inch telescope. (This gap corresponds to 150 astronomical units, or three times the average distance between the Sun and Pluto.) If you're having trouble seeing both components of this star, try observing the double star on a night when the atmospheric seeing is very steady. (Seeing is steady when the bright stars do not twinkle: twinkling is caused by an unsteady atmosphere.) On a night of good atmospheric steadiness, center the star in your telescope's eyepiece and insert the highest power eyepiece that delivers a clean, crisp image. You should see Izar's two components distinctly. Although most observers see the secondary star as blue, some observers have recorded its color as "greenish." What color does it appear to be in your telescope?

T Bootis is one of the sky's greatest historical novae. Its position is just 25′ southwest of Arcturus, easily within the same low-power field of view. But the star itself is no more. T Bootis died in a nova explosion over 125 years ago. The only observations of this star were made by astronomer Joseph Baxendell, who spotted the star as a 9th-magnitude object on April 10, 1860. By April 22, the star had



Variable Stars in Corona Borealis

Orien Ernest

faded to magnitude 12.8, and the following night it was all but invisible. Despite attempts to find a faintly glowing remnant of this star, no one has observed a trace of it since. The mystery of how the star disappeared has never been solved.

Xi (ξ) Bootis is another magnificent double star. To find this star, which forms a right triangle with Arcturus and Izar, aim your telescope toward Arcturus. Move the telescope 8.5° due east, and you will come upon a magnitude 4.5 star surrounded by two curving chains of fainter stars. This is Xi Bootis. Even at low power, you'll see that Xi is a double composed of a magnitude 4.7 and a magnitude 7.0 star separated by about 7″. The stars in the Xi Bootis system offer a fine color contrast for small telescopes. Most backyard observers describe the primary star as yellow and the secondary as ruddy violet.

Corona Borealis contains two bright double stars for small telescopes. To find them, first familiarize yourself with the graceful arc formed by the constellation's brightest stars. **Eta (η) Coronae Borealis** lies 2° northwest of Beta Coronae Borealis, one of the bright stars on the eastern end of the arc. Eta Coronae Borealis offers twin yellow stars of magnitudes 5.6 and 5.9 separated by just under 1″. The slim separation of the components makes this pair a challenging object for a 6-inch telescope under a steady sky. If you don't see this star as a double when you first observe it, keep trying with high powers on nights of steady seeing.

The lovely double star **Sigma (σ) Coronae Borealis** lies 8° northeast of the great arc of stars and 1.5° west of a wide pair formed by Nu^1 and Nu^2 Coronae Borealis. Sigma Coronae Borealis contains magnitude 5.6 and 6.6 stars separated by about 7.5″. Easily visible as a double in any telescope, Sigma's stars glow with a weak tinge of yellow.

The most unusual stars in this part of the sky are two irregular variable stars. **R Coronae Borealis** was discovered in 1795 and was the first known example of a rare type of star. R Coronae Borealis stars, as they are now called, remain at maximum light throughout most of their cycles and fade in brightness only temporarily. Typically R Coronae Borealis glows at magnitude 6, but every two to four years it fades to 9th magnitude or fainter.

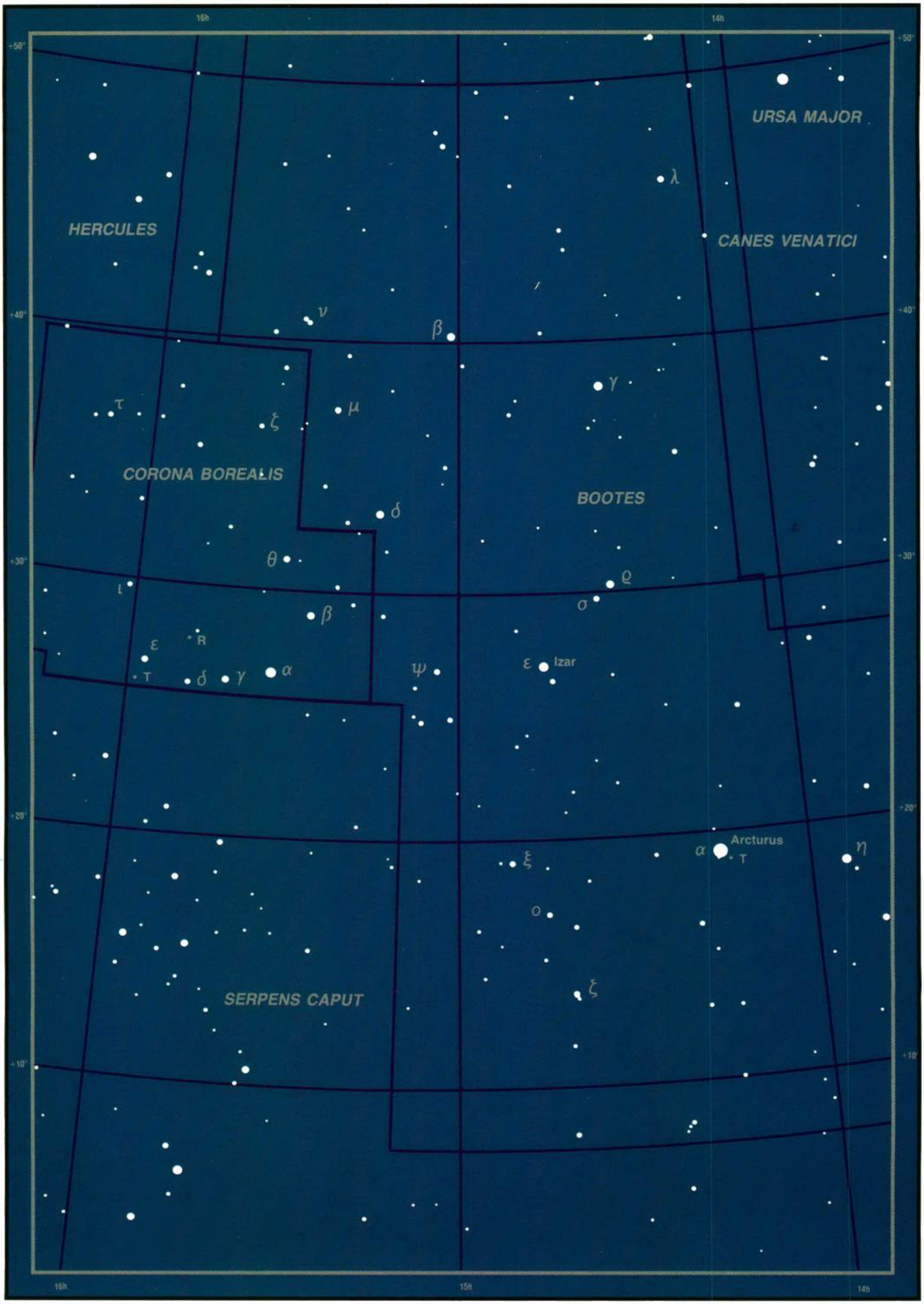
T Coronae Borealis, also the first known of its type, was discovered in 1866. This object lies 1° southeast of Epsilon Coronae Borealis and is one of seven known recurrent novae, stars that display repeating outbursts of light. On May 12, 1866, this star shone at magnitude 2.2 but faded below naked-eye visibility after only eight days. In 1946 the star again flared to naked-eye visibility, though it quickly faded to magnitude 10, where it remains today. However, at any time T Coronae Borealis could flare again. While you're observing in the area, keep an eye on this unpredictable star. After all, the next flare just might happen tonight.

— David J. Eicher

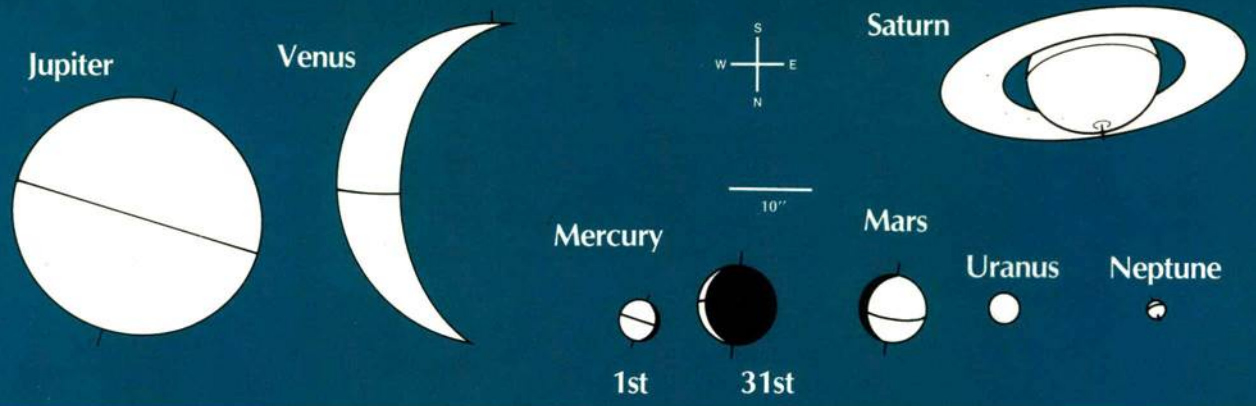
Stars in Bootes and Corona Borealis

Object	Type	R.A. (2000.0) Dec.	Mag.	Size/Sep./Per.
T Boo	N	14h14.1m +19°04′	—	—
Arcturus	★	14h 15.6m +19°11′	−0.06	—
Izar	★^{2}	14h45.0m +27°04′	2.5, 4.9	2.8″
Xi (ξ) Boo	★^{2}	14h51.4m +19°06′	4.7, 7.0	7″
Eta (η) Cor Bor	★^{2}	15h23.2m +30°17′	5.6, 5.9	1″
R Cor Bor	IV	15h48.6m +28°09′	6↔10	irr.
T Cor Bor	IV	15h59.5m +25°55′	2.2↔10	irr.
Sigma (σ) Cor Bor	★^{2}	16h14.7m +33°52′	5.6, 6.6	7.5″

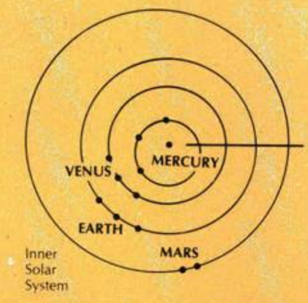
★ star
★^{2} double star
IV irregular variable star
N nova

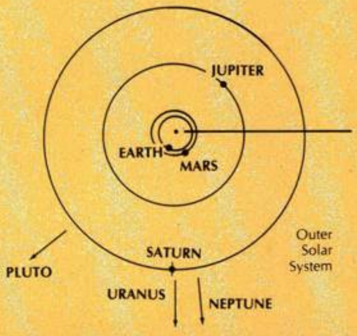

16h
14h
+50°
URSA MAJOR
λ
HERCULES
CANES VENATICI
+40°
ν
β
γ
τ
μ
ζ
CORONA BOREALIS
BOOTES
δ
θ
+30°
ι
ϱ
σ
β
ε
R
ε
Izar
T
δ
γ
α
ψ
+20°
Arcturus
α
T
η
ξ
ο
ζ
SERPENS CAPUT
+10°
16h
15h
14h

Planetary Data May 1988


Jupiter
Venus
S
W
E
N
Saturn
10″
Mercury
Mars
Uranus
Neptune
1st
31st

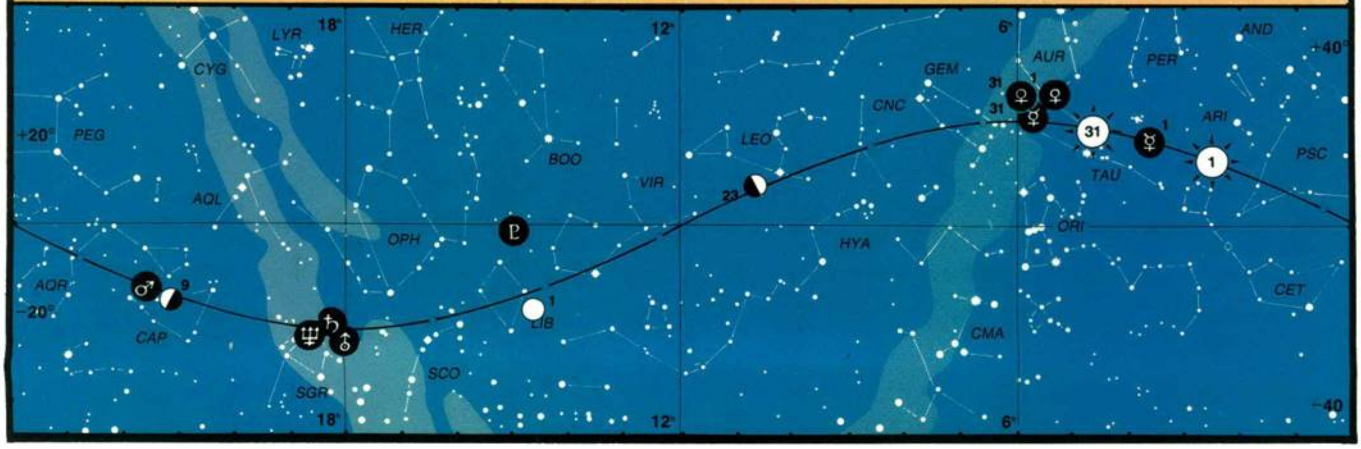
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.7	31.8′	—	1.008	—	—	40°50.6′	2h34.3m	15°07.8′
		15	−26.7	31.6′	—	1.011	—	—	54°23.2′	3h28.7m	18°54.5′
		31	−26.7	31.6′	—	1.014	—	—	69°46.1′	4h33.1m	21°56.5′
Mercury	☿	1	−1.3	5.5″	87%	1.217	0.310	94°22.5′	52°40.2′	3h20.1m	19°42.7′
		15	0.0	7.3″	47%	0.918	0.373	169°29.3′	75°55.5′	4h58.3m	25°08.0′
		31	2.2	10.6″	12%	0.632	0.449	225°30.9′	86°40.9′	5h46.5m	23°38.5′
Venus	♀	1	−4.5	33.6″	33%	0.497	0.721	193°27.6′	82°47.8′	5h28.3m	27°38.9′
		15	−4.5	41.9″	20%	0.398	0.723	215°59.3′	89°09.9′	5h58.0m	27°27.3′
		31	−4.2	53.1″	6%	0.314	0.725	241°33.4′	88°54.5′	5h56.4m	25°28.4′
Mars	♂	10	0.1	8.7″	86%	1.071	1.440	277°31.8′	322°11.2′	21h40.7m	−15°52.1′
		20	0.0	9.4″	85%	0.997	1.429	283°25.1′	328°40.3′	22h06.4m	−13°56.8′
Jupiter	♃	15	−2.0	33.0″	100%	5.976	4.980	43°45.9′	45°42.7′	2h54.1m	15°40.5′
Saturn	♄	15	0.2	17.9″	100%	9.220	10.043	268°09.3′	271°47.9′	18h07.9m	−22°16.1′
Uranus	⛢	15	5.6	3.8″	100%	18.446	19.273	268°37.8′	270°27.6′	18h02.5m	−23°38.8′
Neptune	♆	15	7.9	2.3″	100%	29.509	30.226	278°31.9′	279°59.2′	18h43.5m	−22°04.4′
Pluto	♇	15	13.7	0.1″	100%	28.723	29.666	221°17.2′	221°00.3′	14h54.6m	0°41.4′

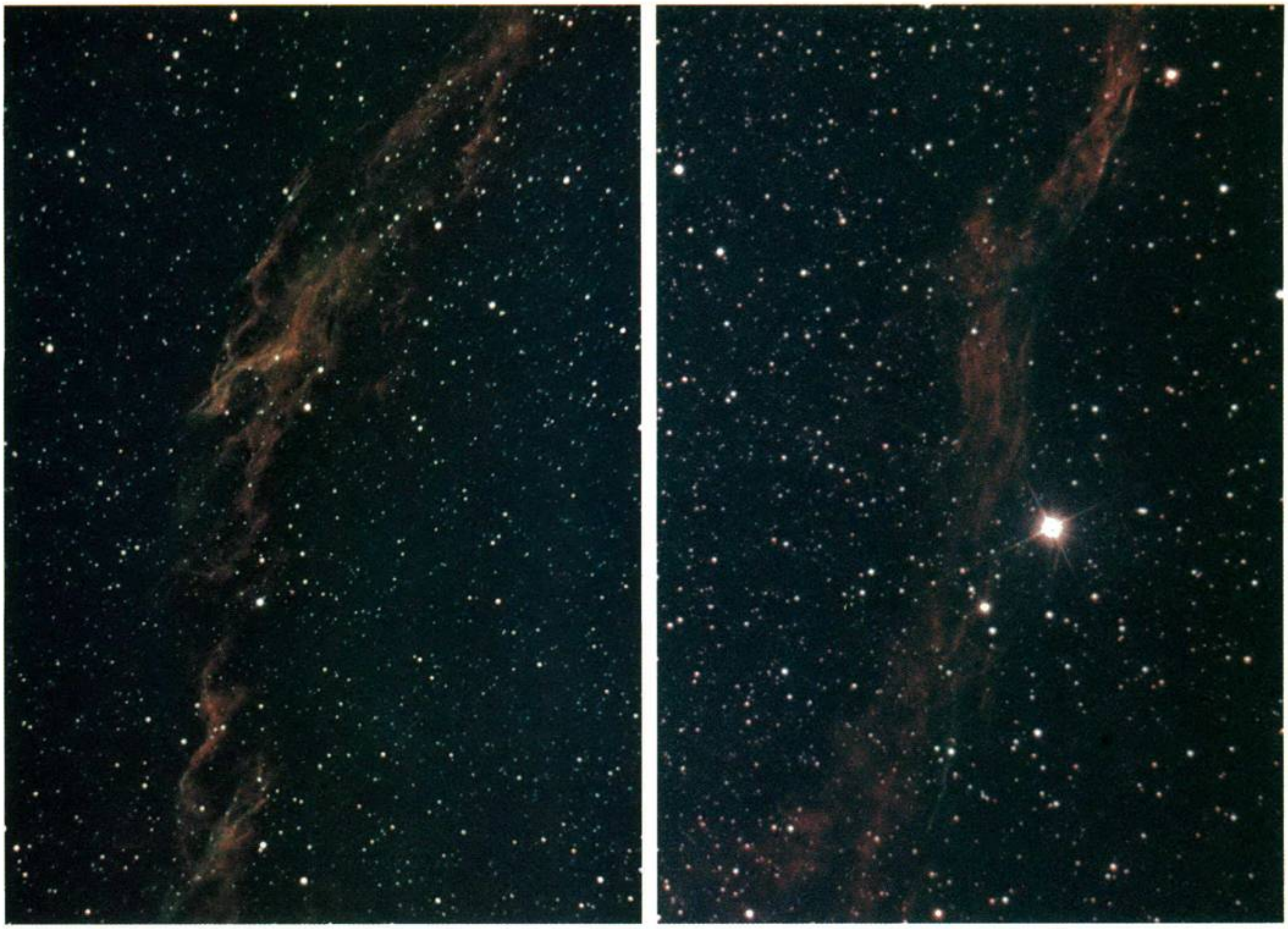

MERCURY
VENUS
EARTH
MARS
Inner
Solar
System


JUPITER
EARTH
MARS
PLUTO
SATURN
URANUS
NEPTUNE
Outer
Solar
System

Moon Data

Full Moon	May 1 at 23h41m
Last Quarter	May 9 at 1h23m
New Moon	May 15 at 22h11m
First Quarter	May 23 at 16h49m
Full Moon	May 31 at 10h53m
Last Quarter	June 7 at 6h21m
Perigee: May 10 at 22h30m	369,066 km
Apogee: May 23 at 13h45m	404,097 km


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
PER
31
1
CNC
31
ARI
+20°
PEG
LEO
31
1
BOO
PSC
TAU
1
VIR
23
AQL
ORI
OPH
HYA
AQR
9
1
CET
−20°
LIB
CAP
CMA
SCO
SGR
18h
12h
6h
−40



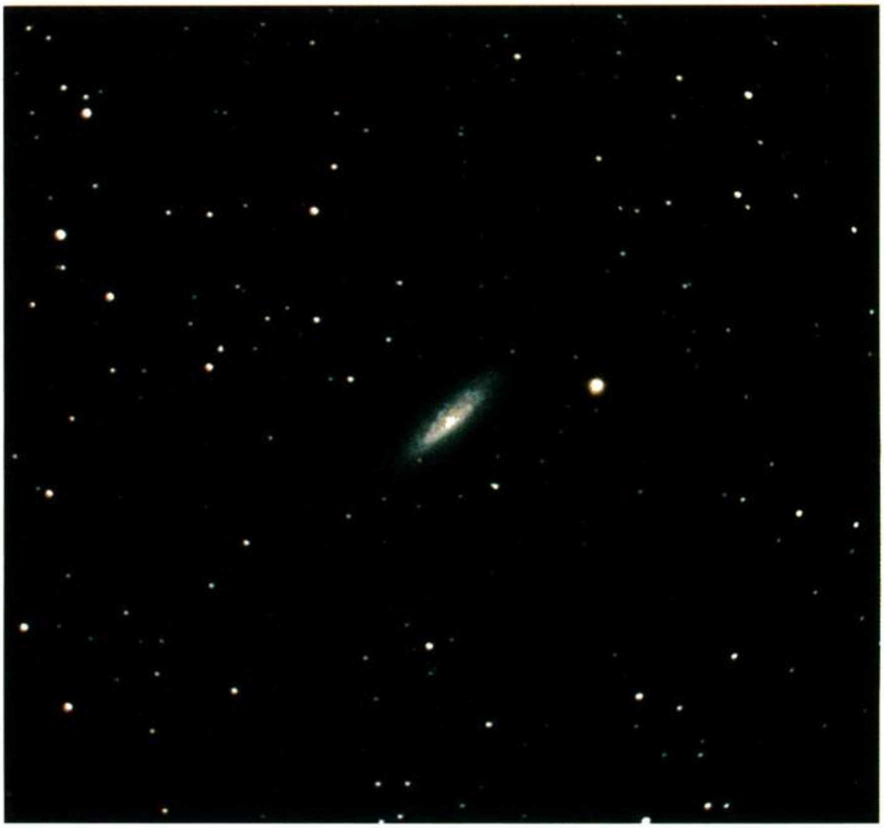
The eastern and western halves of the Veil Nebula in Cygnus glow in these photos like luminescent strands of twine. The eastern half is NGC 6992-5; the western half, shown nearly passing through the bright star 52 Cygni, is NGC 6960. To record NGC 6992-5, Jack Newton exposed VR 1000 film for 25 minutes with a 20-inch f/5 Newtonian and an LPR filter. For the NGC 6960 photo Newton used the same setup with SRV 3200 film, an LPR filter, a cold camera, and a 20-minute exposure.

Planets

Mercury

This month features the year's best opportunity for viewing the planet Mercury. Already 3° high in the northwest on April 30, Mercury quickly climbs toward a peak elevation of 12° on May 15, and will still be 4° high on June 1. (All elevations are for forty-five minutes after sunset.) Greatest eastern elongation, the planet's maximum angular separation from the Sun, comes on the 19th.

On May 1, your telescope at medium magnification will show Mercury as a magnitude −1.3 disk 5.5″ across. As Mercury climbs straight upward from the horizon, its brightness dims (to magnitude 0.5 by the 19th), and its phase changes to resemble a Quarter Moon. After elongation Mercury becomes crescent-shaped as it drops toward the horizon. On June 1,



NGC 6503 is a bright, edge-on galaxy in Draco, visible as a streak of light in a 6-inch telescope. Bill Iburg photographed NGC 6503 with a 14-inch SCT at f/7, hypersensitized Konica SR 400 film, and a 40-minute exposure.

IC 2948, a glowing gas cloud in Centaurus, appears as a ruddy splotch near the center of this photo. It is a 30-minute exposure on Fujichrome RD 100 film made with a 178mm f/2.5 lens. Photo by Chris Schur.

On October 3, 1986, a partial solar eclipse threw a shadow across the United States. Bruce Borich's composite photo of the event as seen from downtown Orlando, Florida, is this month's $100 "Best Astrophoto" award winner. Borich used a 35mm Nikkor at f/22 for the photograph.

the planet appears only 10 percent illuminated; its magnitude is then 2.4, and its angular diameter is 10.9″.

Some observing practicalities: bad seeing at low elevations will prevent crisp, undistorted views. Once you locate Mercury, try observing it somewhat earlier the next night. It will then be higher and the lingering twilight will reduce the halo of scattered glare in your eyepiece.

Venus

As it moves down to join Mercury (see Eye on the Sky), Venus becomes an arresting sight in a telescope. In May its apparent size grows from 34″ to 53″, but the most striking aspect is the way Venus' disk is thinning down to a very skinny crescent, especially during the last two weeks of the month. It is worth trying to observe Venus at every opportunity this month: you will be able to see small yet distinct changes in Venus' appearance if you observe just a few days apart.

Remember, though, as with Mercury, poor "seeing" near the horizon and the glare from the brilliant white planet will greatly reduce the visibility of the changes. To get the best view, locate Venus right after sunset and observe while the skylight around its disk cuts the contrast to a tolerable level.

Mars

Rising about four hours ahead of the Sun, Mars is conveniently placed for viewing in the southeastern sky as morning twilight begins. On the 15th, Mars' diameter is 9.1″, big enough to show more than just the largest and coarsest surface features. (Because contrast can be a problem with Mars as with Mercury and Venus, keep observing well into twilight.)

Mars' southern hemisphere is tipped toward us by about 23° this month, which affords a clear look at Mars' south polar cap. Luckily Mars is less tipped as seen from the Sun, so we will be able to view the ice cap for a month or two more before the Sun moves far enough south on Mars to melt the ice cap.

Minor Planets

1 Ceres (magnitude 8.8) lies in eastern Aquarius where it rises a few hours before morning twilight begins. Its positions:

1st: 23h18m40s, −13°46.1′
10th: 23h29m45s, −13°00.1′
20th: 23h41m21s, −12°15.4′
30th: 23h52m04s, −11°38.6′

2 Pallas (10.1) is moving northeast in Delphinus and will be high enough for viewing by midnight. Its positions:

1st: 20h41m57s, 13°29.3′
10th: 20h45m45s, 14°34.1′
20th: 20h48m23s, 15°41.7′
30th: 20h49m12s, 16°41.8′

3 Juno is in conjunction with the Sun on the 23rd and out of view all month.

4 Vesta (7.9) is moving eastward in central Cancer where it passes about 3-1/2° north of M44 (the Beehive Cluster) on the 15th. Its positions:

1st: 8h21m53s, 24°32.4′
10th: 8h33m34s, 23°51.9′
20th: 8h47m41s, 22°59.0′
30th: 9h02m45s, 21°57.9′

Start looking for Vesta as soon as it gets dark, because by the end of twilight Cancer lies west of the meridian and is descending.

14 Irene (10.2) sweeps past 2nd-magnitude Denebola (*β* Leonis) between May 12 and 17, passing closest (15′ to the northeast) on the 15th. Irene's positions:

1st: 11h36m41s, 17°24.0′
10th: 11h38m09s, 16°14.0′
20th: 11h42m25s, 14°40.3′
30th: 11h49m06s, 12°54.2′

At nightfall Leo lies high in the south.

43 Ariadne (9.2) reaches opposition on May 27, in Scorpius near the globular cluster M80. Its positions:

1st: 16h40m09s, −25°28.7′
10th: 16h35m37s, −25°06.3′
20th: 16h27m35s, −24°28.1′
30th: 16h18m01s, −23°38.3′

Ariadne will be high enough for viewing by about 11 p.m.

To locate a minor planet, photocopy the appropriate chart from a good star atlas (*Sky Atlas 2000.0* or *Uranometria 2000.0*, for example), plot the object's dated positions lightly in pencil, and sketch a smooth curve linking the points. The positions are for 0h UT in epoch 2000.0 coordinates.

Then observe the starfield at low magnification and photograph or plot by hand what you see. Recheck the field a night or two later; the "star" that has moved is the minor planet.

Jupiter

Because Jupiter is in conjunction with the Sun on May 2, it isn't visible until the last few days of the month, when it appears very low in the northeast during the hour before sunrise. At magnitude −2.0 Jupiter appears 33″ across in a telescope, but because of its low elevation, you'll have difficulty seeing any details on Jupiter's disk.

Saturn

Located in Sagittarius, Saturn rises in the late evening hours and is then visible until sunrise. The best telescopic views will most likely be at 100x to 150x, enough to show Saturn's disk clearly and to reveal the main structure of the rings, but not so high that shimmer from poor seeing degrades the image. Saturn's disk spans 18″ while the rings spread 41″.

Uranus

Uranus lies about 2° south of Saturn and offers a featureless disk 3.8″ across. During May Uranus is creeping retrograde (westward) in between the Lagoon and Trifid nebulae (M8 and M20). The planet appears as a 6th-magnitude star in your finder scope, but 100x will show its blue-green disk.

Neptune

Located about 40 minutes of right ascension (10°) due east of Saturn, Neptune lies north of the "Teapot" in Sagittarius. To find Neptune, start at Lambda (λ) Sagittarii (the top of the Teapot's lid) and then scan 2-1/2° northeast to find the globular cluster M22. Neptune at 8th magnitude with a 2.3″ blue-gray disk lies 2-1/2° farther northeast of M22.

Pluto

Pluto is at opposition on May 1, but isn't any brighter than magnitude 13.7. Viewing it calls for a large telescope (8-inch minimum) and a run of several clear nights over about a week. Use a star atlas to locate the named stars surrounding Pluto's track on the finder chart (see the January issue, page 108) and then zero in on the part the planet follows in May.

Plot everything in the eyepiece field (by hand or photo) down to at least 14th magnitude and recheck the field a day or two later. The "star" that has moved northwest is Pluto.

— *Robert Burnham*

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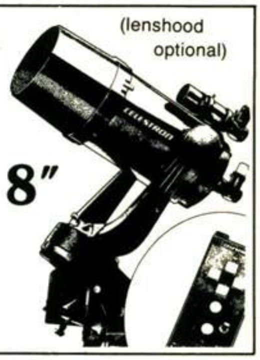

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